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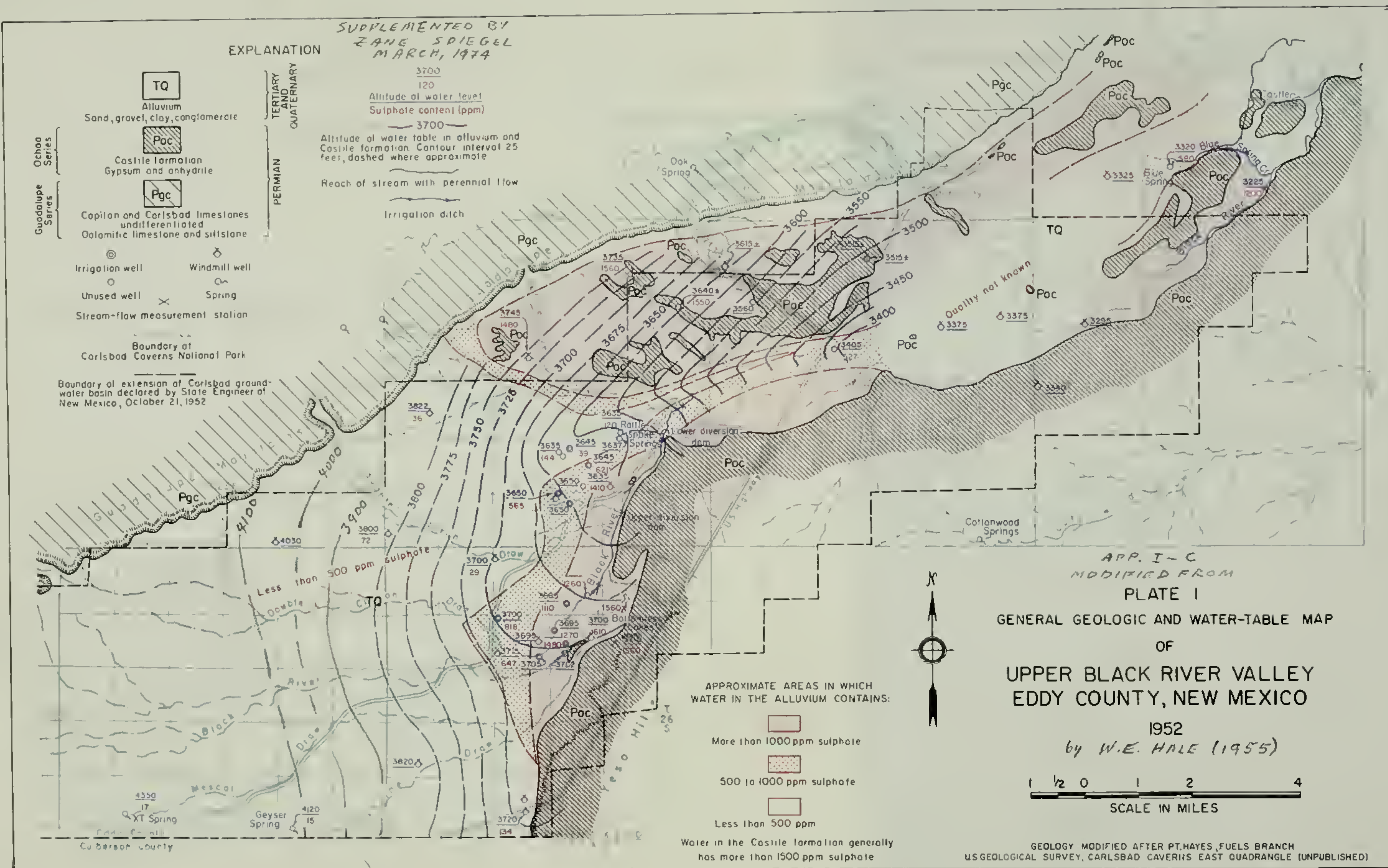
STATE OF NEW MEXICO
State Engineer Office

John R. Erickson
State Engineer

GROUND-WATER CONDITIONS IN THE VICINITY OF RATTLESNAKE SPRINGS, EDDY COUNTY, NEW MEXICO

Prepared in cooperation with the
Geological Survey and National Park Service,
United States Department of the Interior

January 1955


SUPPLEMENTED BY
ZANE SPIEGEL
MARCH, 1974
EXPLANATION
TQ
Alluvium
Sand, gravel, clay, conglomerate
TERTIARY AND QUATERNARY
Ochoa Series
Poc
Castile formation
Gypsum and anhydrite
PERMIAN
Guadalupe Series
Pgc
Capitan and Carlsbad limestones undifferentiated
Dolomitic limestone and siltstone
Irrigation well
Windmill well
Unused well
Spring
Stream-flow measurement station
Boundary of Carlsbad Caverns National Park
Boundary of extension of Carlsbad ground-water basin declared by State Engineer of New Mexico, October 21, 1952
3700
120
Altitude of water level
Sulphate content (ppm)
3700
Altitude of water table in alluvium and Castile formation. Contour interval 25 feet, dashed where approximate
Reach of stream with perennial flow
Irrigation ditch
Oak Spring
Rattlesnake Springs
Lower diversion dam
Upper diversion dam
Blue Spring
Cottonwood Springs
Geyser Spring
XT Spring
Black River
Double Canyon
Quality not known
Less than 500 ppm sulphate
APPROXIMATE AREAS IN WHICH WATER IN THE ALLUVIUM CONTAINS:
More than 1000 ppm sulphate
500 to 1000 ppm sulphate
Less than 500 ppm
Water in the Castile formation generally has more than 1500 ppm sulphate
N
APP. I-C
MODIFIED FROM
PLATE I
GENERAL GEOLOGIC AND WATER-TABLE MAP
OF
UPPER BLACK RIVER VALLEY
EDDY COUNTY, NEW MEXICO
1952
by W.E. HALE (1955)
1 1/2 0 1 2 4
SCALE IN MILES
GEOLOGY MODIFIED AFTER P.T. HAYES, FUELS BRANCH
U.S. GEOLOGICAL SURVEY, CARLSBAD CAVERNS EAST QUADRANGLE (UNPUBLISHED)

View of stream below Rattlesnake Spring, looking north to Guadalupe Mountains, on skyline. Conglomerate exposed in middle ground. Photo by Edward D. Heath, 1945.

STATE OF NEW MEXICO

STATE ENGINEER OFFICE
TECHNICAL DIVISION

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by

W. E. Hale, Engineer
U. S. Geological Survey

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Reports Section
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State Engineer Office
Santa Fe, New Mexico
1955

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GROUND-WATER CONDITIONS IN THE VICINITY OF RATTLESNAKE SPRINGS, EDDY COUNTY, NEW MEXICO

by
W. E. Hale
U. S. Geological Survey

ABSTRACT

The flows of Rattlesnake Springs, Blue Spring, and the Black River in the upper Black River valley in southwestern Eddy County, N. Mex., are utilized mostly for irrigation. Part of the water from Rattlesnake Springs also is pumped by the National Park Service for use at the Carlsbad Caverns about 5.5 miles distant. Concern over the possible effects of pumping of recently developed irrigation wells in the area on the surface-water supply prompted an investigation by the U. S. Geological Survey, in cooperation with the State Engineer of New Mexico and the National Park Service.

The upper Black River valley is bounded on the northwest by the Guadalupe Mountains and along the southeast by hills of low relief which near the State line are called the Yeso Hills. The valley is 4 to 9 miles wide. The Black River, the principal stream, heads in the Guadalupe Mountains. Its course is normally dry in the mountains and across the alluvial fan at the mouth of Black Canyon. A perennial stretch of about 4 miles starts about 4 miles north of the State line. Below this stretch and in a northeastward direction the channel is normally dry for a distance of about 10 miles. From the lower end of the normally dry channel to the Pecos River, a distance of roughly 20 miles, the river has a perennial flow. The chief source of water in the lower perennial stretch of the Black River is Blue Spring.

Alluvium, ranging in thickness up to 200 feet, is the principal source for important ground-water supplies in the upper Black River valley. Recharge to the alluvium probably occurs mostly from flood waters originating in the canyons of the bordering Guadalupe Mountains. These flood waters percolate into the alluvium in the canyons and the alluvial fans at the mouths of the canyons. Occasionally, flood waters reach the lower courses of the various draws. Water moves through the alluvium in a general northeastward direction down the valley of Black River. Accretions to the water in the alluvium occur, in part, by movement of water from adjacent shallow water-bearing beds in gypsum of the Castile formation. Recharge to the shallow aquifer in the Castile formation occurs mostly from precipitation in the area of outcrop of the formation. Water in the gypsum has a high calcium sulfate content, and where this water moves into the alluvium it mixes with water of better quality in the alluvium. Thus a progressive increase in mineral content occurs as the water moves through the alluvium down the valley.

Irrigation from wells in upper Black River valley reportedly began in 1946 with the irrigation of 18 acres in sec. 3, T. 26 S., R. 24 E., about 3.5 miles south of Rattlesnake Springs. Further development was slow until 1951. During 1952 approximately 670 acres were being irrigated from wells in the upper valley and a substantial part of the acreage was within 2 miles of Rattlesnake Springs. Wells having yields of as much as 1,300 gallons a minute are developed in the conglomeratic beds in the alluvium.

The upper perennial stretch of the Black River extends from sec. 3, T. 26 S., R. 24 E., northward about 4 miles. The river begins to lose water to the underlying alluvium in the lower half mile of this stretch, and the dry-weather flow disappears in the NE$\frac{1}{4}$ sec. 24, T. 25 S., R. 24 E. The maximum dry-weather flow is about 2 to 3 cfs. The average annual discharge of wells in the area immediately upstream from this perennial stretch is about 0.7 cfs; estimating about a 30-percent return from irrigation, the net withdrawal of water is about 0.5 cfs. The effect of this pumping has probably reached the springs at the head of the upper perennial stretch, about 3.5 miles above Rattlesnake Springs, but it probably will reduce their flow by less than 0.3 cfs in the next few years, if the pumping in the locality is not increased. An observed decline in the flow of these headward springs from 1.0 cfs in October to 0.7 cfs in December 1953 probably was caused largely by the continued below-normal recharge resulting from a 50-percent deficiency in normal precipitation during 1951-53.

Rattlesnake Springs issues from the alluvium in a developed pool on the flats of Nuevo Canyon Draw in the SW$\frac{1}{4}$ sec. 23, T. 25 S., R. 24 E. The discharge of the springs, as observed from periodic measurements, has ranged between 1.7 and 4.2 cfs, the smaller flow coinciding with pumping from nearby irrigation wells. The aquifer discharging water at Rattlesnake Springs also is tapped by four irrigation wells. The seasonal discharge from these wells in 1953 was approximately equivalent to the decrease in discharge of Rattlesnake Springs, allowing for some decrease in the spring discharge caused by drought conditions. An increase in the pumpage from these wells or the development of additional wells in the locality southwest from Rattlesnake Springs would result in further decline in the flow of the springs, and the springs might cease to flow near the end of the irrigation season.

Blue Spring, in the NW$\frac{1}{4}$ sec. 33, T. 24 S., R. 26 E., with a discharge of approximately 12 cfs, probably is the principal discharge point for the water in the alluvium in the Black River valley westward from Blue Spring. The present average net diversion of ground water caused by pumping of irrigation wells in upper Black River valley is of the order of 1 cfs. This should result in a decline in the flow of Blue Spring of approximately this amount within a few months or several years, depending upon whether the water occurs under water-table conditions in fairly open channels or under artesian conditions.

INTRODUCTION

Investigation of the ground-water conditions in the vicinity of Rattlesnake Springs in southern Eddy County, N. Mex., was begun in April 1952 by the United States Geological Survey and the State Engineer of New Mexico, with the cooperation of the National Park Service (fig. 1).

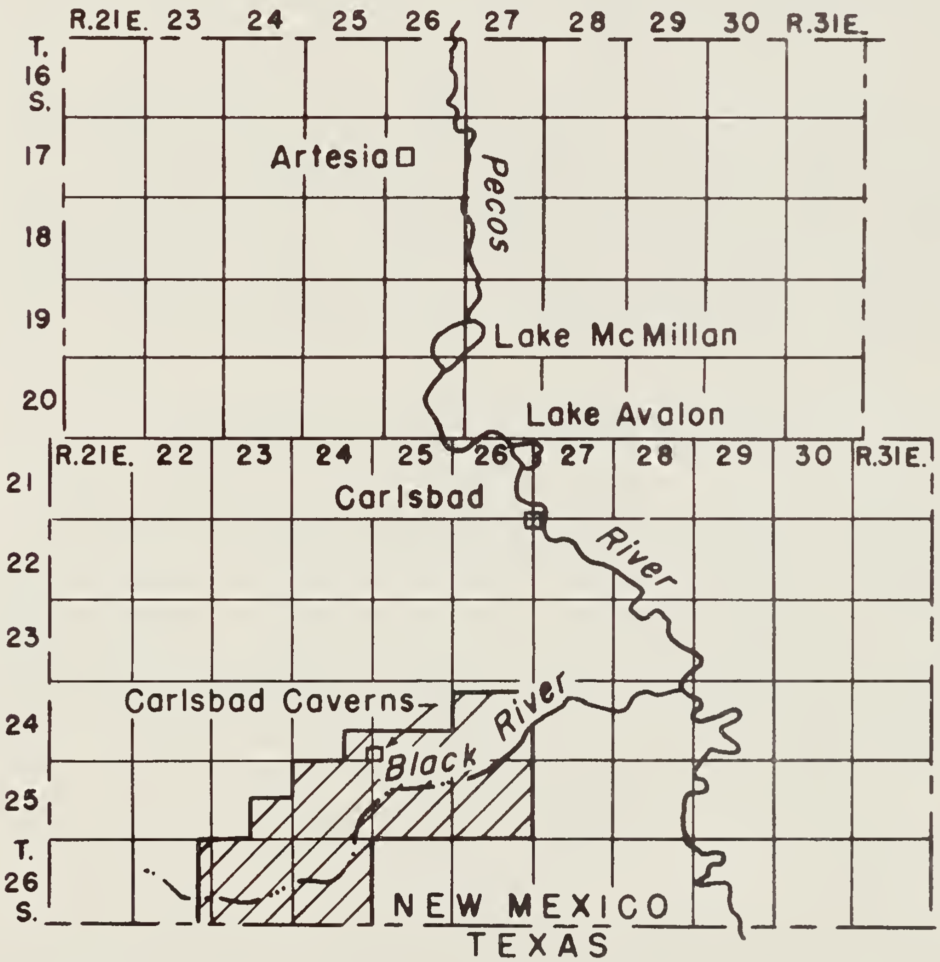

Figure 1.--Area (hachured) covered by this investigation.

The waters of the Black River and Rattlesnake Springs have been used for the irrigation of lands in the vicinity of Rattlesnake Springs for many years. In addition, a part of the flow of Rattlesnake Springs is pumped through a pipeline by the National Park Service for use at the Carlsbad Caverns, approximately 5.5 miles distant. A part of the flow of the springs also is used by

the State Department of Game and Fish to maintain a few pools for fish and wildlife along the Rattlesnake Springs drainageway, and part of the flow from both the springs and the Black River maintains pools along the Black River in the lower part of its upper perennial stretch, that in the vicinity of Rattlesnake Springs.

Below these pools the Black River is normally dry for a distance of 10 miles, below which the river has a perennial flow to its junction with the Pecos River. Blue Spring is the principal source of the water in Black River in its lower stretch, and water from this spring and the Black River is utilized by the Carlsbad Irrigation District and other parties for irrigation.

Water reportedly was first pumped from wells in 1946 near Rattlesnake Springs in the upper Black River valley for the irrigation of lands, when water was applied to about 18 acres of land along the Black River about 3.5 miles upstream from Rattlesnake Springs. Development of additional lands by means of irrigation from wells was not appreciable until 1951. During 1952, approximately 670 acres were irrigated from wells, and a large part of this acreage was within 2 miles of Rattlesnake Springs.

Purpose and Scope of the Investigation

With the construction of wells for irrigation use within 2 miles of Rattlesnake Springs, the National Park Service became concerned as to what effect this and possible further development of irrigation wells in the locality might have on the flow of the springs. The State Department of Game and Fish also was concerned about the effects of nearby pumping on the flow of the Black River as well as Rattlesnake Springs. Further, there was the question as to what effect pumping from these wells might have upon the flow of Blue Spring and the Black River farther down the valley. The State Engineer, because of his responsibilities in the administration of water rights of both ground water and surface water in the State, was concerned as to the relation of ground water to surface water in the area.

This investigation was made to determine the ground-water conditions in the upper Black River valley, the relation of ground water to surface water in the area, and the effect of the pumping of wells, if any, on the flow of Rattlesnake Springs and other surface waters. This report discusses principally the relation of ground water to Rattlesnake Springs, and the effects of pumping from wells in the area on the flow of these springs.

Previous Investigations

Considerable study has been made of the geology of the general area, mostly by oil geologists and members of the Geological Survey, particularly in the past 20 years, because of the relation of the rocks exposed in this general area to those from which oil is obtained in the subsurface farther east in southeastern New Mexico and west Texas. The work by the several investigators has been published largely in bulletins of the American Association of Petroleum Geologists and by the Geological Survey, and the several endeavors have resulted in a general clarification of the complex geology of the region. One of the most important recent works on the region is that by King (1948). Reference to studies in the area prior to 1940 is given by King, and the reader is referred to King's report for more detail on the geology of the area covered by this investigation. During 1952 and 1953 the 15-minute quadrangle, identified as Carlsbad Caverns East, N. Mex., was mapped geologically by P. T. Hayes of the Fuels Branch of the Geologic Division of the Geological Survey. His work covered a large part of the area included in this investigation, and although the report on the quadrangle is still in preparation, the results of the work were kindly made available for use in this report. Thus the work of King, Hayes, and several others is drawn on in the discussion of the general geology of the area in this report, without particular reference to the various works.

The general ground-water conditions in the area of this investigation are described in a report by Hendrickson and Jones (1952) which was a result of an investigation made by the Geological Survey in cooperation with the State Bureau of Mines and Mineral Resources and the State Engineer of New Mexico. Information in that report also has been drawn on freely in the preparation of the present report.

Present Investigation

Intensive field work in the area was done by E. H. Herrick, geologist, Geological Survey, and the writer from April through June 1952. It involved the collection of well data, measurement of water levels, determination of elevations at wells, and collection of water samples for mineral analyses. A network of observation wells was established, and arrangements were made for the measurement at monthly intervals of the flow of Rattlesnake Springs, Blue Spring, and the Black River at several places. The investigation is being continued as part of an investigation of the Carlsbad, N. Mex., area through the measurement of depths to water level in observation wells and of the flow of surface water, together with additional studies of the relation of ground water to surface water in the vicinity of Blue Spring.

Personnel and Acknowledgments

This investigation was made under the general direction of A. N. Sayre, Chief of the Ground Water Branch of the Geological Survey, and Clyde S. Conover, District Engineer of the Branch for New Mexico, and under the direct supervision of the writer. Measurements of surface-water flows were made under the direction of S. O. Decker of the Surface Water Branch. The general geologic map is a modification of the map prepared by P. T. Hayes, of the Geologic Division. Personnel of the State Engineer Office assisted with the work, and special acknowledgment is due J. C. Yates and S. E. Galloway of that office for their work in collecting well data, running spirit levels, and determining the irrigated acreage. Lester Stroup of the State Department of Game and Fish, personnel of the National Park Service, and the well owners in the area were helpful in giving pertinent information on the area.

Well-Numbering System

The system of numbering wells in this report is the same as that used in other parts of New Mexico by the Ground Water Branch of the U. S. Geological Survey. This system is based on the common subdivisions in sectionized land, and by means of it the well number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land net. The number is divided into four segments by periods. The first segment denotes the township, the second denotes the range, and the third denotes the section. In Eddy County all the townships are south of the base line and east of the principal meridian.

The fourth segment of the number consists of three digits and denotes the particular 10-acre tract in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1,2,3, and 4, and in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fourth segment gives the quarter section, which is normally a 160-acre tract. Similarly, the quarter section is divided into 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 25.24.27.124 is in the SE$\frac{1}{4}$NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 27, T. 25 S., R. 24 E. If the well is not located accurately to a 10-acre tract, a zero is used as the third digit, and if it is not located accurately to a 40-acre tract, zeros are used for both the second and third digit. If the well is not located more accurately than the section, the fourth segment of the well number is omitted. Letters a, b, c,-----are added to the fourth segment to designate the second, third, fourth, and succeeding wells situated in the same 10-acre tract. The following diagram shows the method of numbering the tracts within a section.

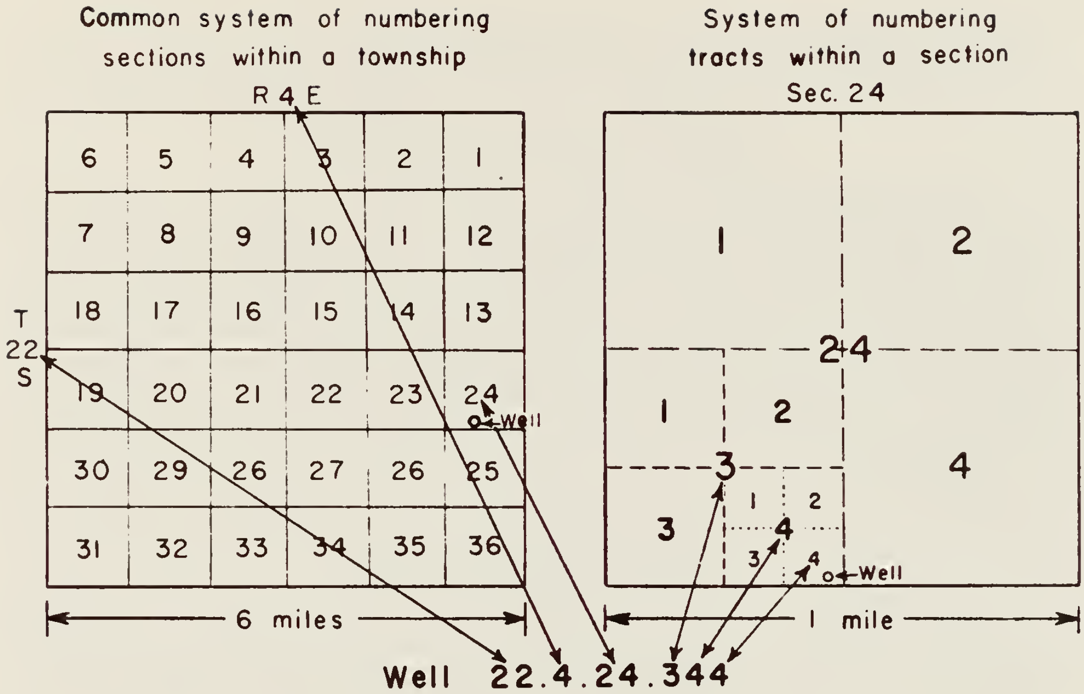

Figure 2. --System of numbering wells in New Mexico.

GEOGRAPHY

Location and Extent of the Area

The area included in this investigation is in the upper Black River valley in the southwestern part of Eddy County and extends upstream from the vicinity of Black River Village to the New Mexico-Texas State line (pl. 1). This area of about 200 square miles in southeastern New Mexico coincides approximately with the extension of the Carlsbad ground-water basin declared by the State Engineer on October 21, 1952, after the investigation was started (pl. 1). The main emphasis of the study is centered around Rattlesnake Springs.

Topography and Drainage

The Black River valley headward from Black River Village is bounded on the north and west by the Guadalupe Mountains and along the south and east by hills and bluffs of low relief which near the State line are called the Yeso Hills. The valley bottom slopes northeastward at approximately 25 feet per mile. The actual flood plain of the Black River is, in general, only a few hundred feet wide, but coalescing alluvial fans border the flood plain to the north and west and make the entire valley 3 to 4 miles wide in the stretch between Black River Village and Rattlesnake Springs. From Rattlesnake Springs headward, the valley widens to about 9 miles at the State line.

The general relief of the alluvial fans from Black River to the foot of the Guadalupe Mountains, as determined from topographic maps, ranges from 250 feet near Black River Village to more than 700 feet in the southwestern part of the area.

Guadalupe Ridge, the eastern limb of the Guadalupe Mountains in this locality, terminates along its southeast side in an even scarp referred to as the "reef escarpment." The height of the ridge above the adjacent alluvial fans ranges from 300 feet in the northeast part of the area to about 2,000 feet in the southwestern part. Guadalupe Ridge is dissected by many canyons in the area, some of the most prominent being Walnut, Rattlesnake, Slaughter, and Black canyons.

The principal drainageway is the Black River, whose channel in general borders the low hills along the southeast side of the Black River valley. The river is normally dry along its course in the mountains and across the alluvial fan extending eastward from the mouth of Black Canyon. Perennial flow occurs in a 4-mile stretch of the river starting from a series of springs (called the headward springs in this report) in the south part of sec. 3,

T. 26 S., R. 24 E., about 3.5 miles south of Rattlesnake Springs. The flow of the Black River, at the station below Mayes Ranch in the NE¼SE¼ sec. 3, T. 26 S., R. 24 E., just below the headward springs, was about 1 cfs during most of 1953.

Downstream about 1.5 miles from the headward springs, a dam has been constructed and maintained on the river for several years for use in diverting water for irrigation of lands in parts of secs. 23, 24, 25, and 26, T. 25 S., R. 24 E. (fig. 4). Some water can be stored behind the dam, known as the upper diversion dam, permitting the diversion of water at much greater rates than the natural flow in the river. Water is run through the diversion canal only during periods of actual irrigation of lands. Periodic measurements of the flow of the Black River made just below the upper diversion dam in the SE¼NW¼ sec. 35, T. 25 S., R. 24 E., at times when water was not being diverted, indicate flows ranging between 1 and 3 cfs. The lower flows, about 1 cfs, measured during the irrigation season presumably in part result from the incomplete recovery of the storage behind the diversion dam from a previous diversion period. During periods of diversion of water from the river the water level in the storage pool behind the dam is lowered below the spillway of the diversion dam. Some leakage occurs through the dam to maintain a small flow down the river channel while water is being diverted through the main canal. After the gate to the canal is closed, the storage behind the dam increases until the discharge over the spillway and through the dam equals the inflow. The lower flows during the irrigation season, about 1 cfs, presumably were measured shortly after diversion of water had ceased, during the period of adjustment to stable nondiversion conditions. A gain of 1 to 1.5 cfs occurs between the headward springs and this station.

Another dam located farther downstream in the SE¼ sec. 24, T. 25 S., R. 24 E., known as the lower diversion dam, is used to divert water to a small acreage in section 24. Very little water can be stored, and as a result the rate of diversion is about that of the natural flow in the stream. Periodic measurements made on the flow of the Black River just above the lower diversion dam indicate a dry-weather flow ranging between 0.3 and 3.2 cfs. The extremely low flows were observed during the irrigation season when water was being diverted at the upper diversion dam. Generally, under natural conditions, the stream gains a fraction of a cfs between the station below the upper diversion dam and this point (see table 4).

Below the lower diversion dam in the southwest part of sec. 24, T. 25 S., R. 24 E., loss of water in the channel occurs and the dry-weather flow ceases in the northeast part of the section. From this point downstream about 10 miles to the south part of sec. 4, T. 25 S., R. 26 E., the Black River is normally dry. Just above the junction with Blue Spring Creek in sec. 35, T. 24 S.,

R. 26 E., the normal flow of the Black River in 1953 was about 0.3 cfs. Blue Spring Creek contributes a substantial part of the flow of the Black River, and the river has a perennial flow from this confluence to its junction with the Pecos River.

Several springs occur in the valley of Black River, the largest of which is Blue Spring. This spring, with a flow of more than 11 cfs, is in the north part of sec. 33, T. 24 S., R. 26 E. The water from this spring forms Blue Spring Creek which joins Black River about 2 miles to the east. The next largest spring in the area is Rattlesnake Springs in the southwest part of sec. 23, T. 25 S., R. 24 E. From April 1952 through June 1954, the observed flow from this spring area ranged between 1.7 and 4.2 cfs. Other named springs include XT Spring and Geyser Spring in the southern part of the area. The results of spot discharge measurements made at Castle Springs, Blue Spring, Rattlesnake Springs, and various places on the Black River are given in table 4, and hydrographs for most of these stations are presented in figure 3.

Precipitation

Stations for recording precipitation have been maintained by the Weather Bureau for a number of years at Carlsbad Caverns on the north side of the area and at Carlsbad, Eddy County, about 20 miles northeast of the area. The upper valley of the Black River is somewhat higher than the Carlsbad station and, in general, about 800 feet below the Carlsbad Caverns station. The average precipitation in the area of investigation is probably about an average of that at the two stations. About 75 percent of the precipitation occurs from May through October, but even in normal years it is not sufficient for dry farming. During 1951, 1952, and 1953 precipitation in the area was approximately 50 percent of normal, as shown in the following tabulation of the precipitation at Carlsbad and the Carlsbad Caverns. Storms in this area generally are quite local, and hence runoff and recharge in parts of the area may not correlate in detail with the precipitation recorded at the Carlsbad and Carlsbad Caverns stations.

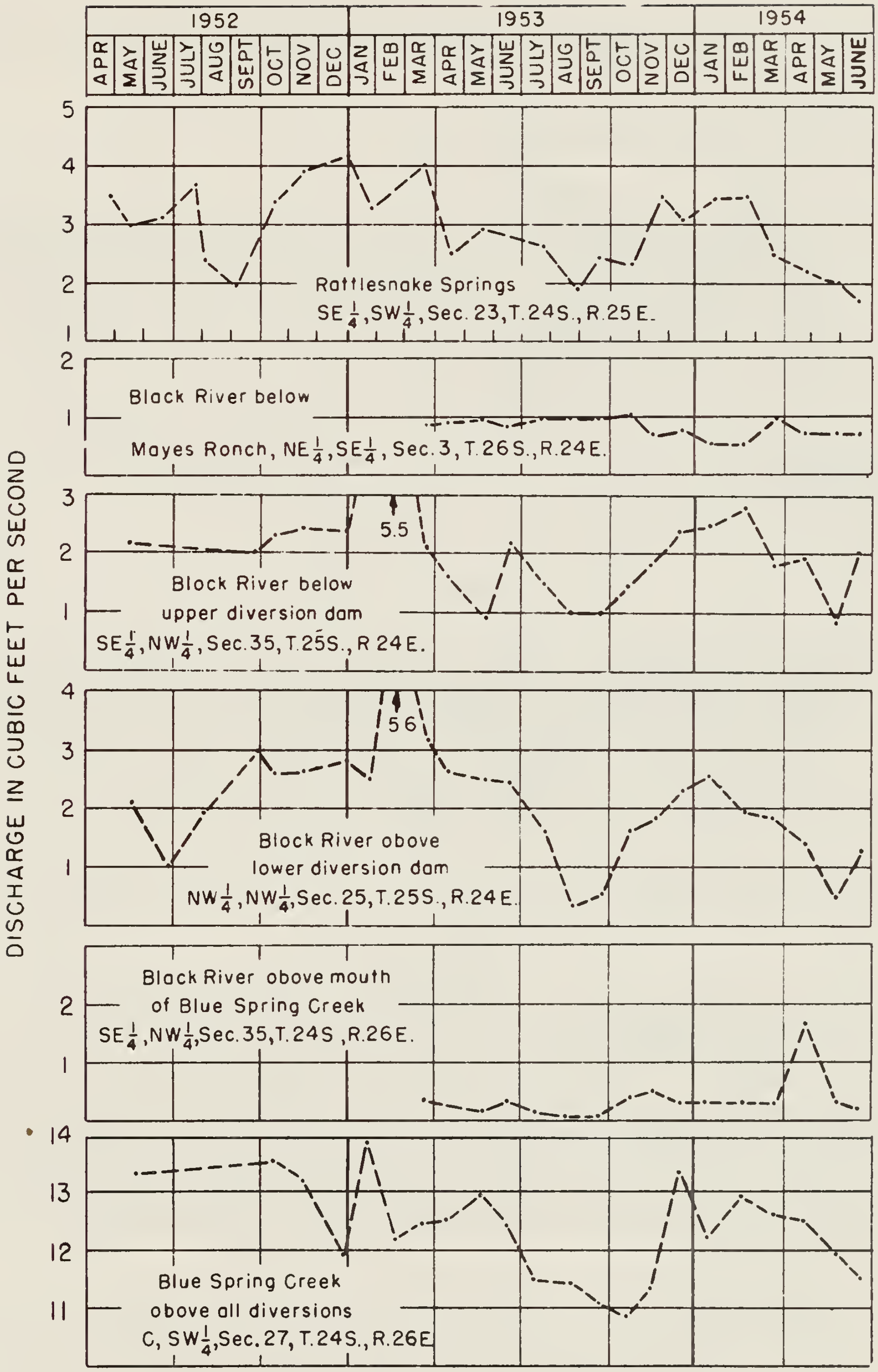

Figure 3.--Hydrographs of spring and stream flow in the upper Black River valley, Eddy County, N. Mex., 1952-54 (Periodic measurements represented by dots.)

Precipitation in inches for 1951-53 and average for period of record
(from records of the U. S. Weather Bureau)

Carlsbad

Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1951	0.14	0.34	1.05	0.67	1.17	0.05	0.96	1.78	0.05	0.22	0.00	0.00	6.43
1952	.15	.17	.10	.42	.51	2.21	E2.03	.16	.61	.00	.73	T	E7.09
1953	.02	.01	.44	.35	1.05	.43	1.69	.47	.16	.93	.00	.42	5.97
Average for station (59 years)	.39	.37	.52	.76	1.16	1.72	2.12	1.78	1.91	1.44	.53	.55	13.25

E. Estimated.

T. Trace, less than .01 inch.

Carlsbad Caverns

Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1951	0.08	0.30	1.48	0.09	0.55	0.24	0.51	0.61	0.30	0.21	0.07	0.03	4.47
1952	.09	.10	.13	1.14	.68	1.78	3.38	.18	.81	.00	.66	.13	9.08
1953	.03	.06	.02	.68	1.19	2.07	1.16	.61	.01	.98	.11	.94	7.86
Average for station (24 years)	.59	.43	.41	.63	1.73	1.68	2.03	1.98	3.27	1.55	.45	.60	15.35

Agriculture

In most of the area the land is used for grazing cattle. Small tracts along the Black River and Grapevine Draw have been irrigated for a number of years by water diverted from the Black River, Rattlesnake Springs, and Geyser Spring. About 60 acres are reported to be irrigated from Geyser Spring. In the vicinity of Rattlesnake Springs, the area irrigated from the springs and the Black River varies somewhat from year to year, but it is estimated that 250 acres were irrigated in this locality from surface waters (including spring water) in 1953 (fig.4).

Development of irrigation from wells in the vicinity of Rattlesnake Springs began in 1946 with the farming of about 18 acres in sec. 3, T. 26 S., R. 24 E. There was little increase in acreage irrigated from wells until 1951. The following table shows the development of irrigated lands in the upper Black River area. Irrigated acreage prior to 1951 is reported by the different owners; that for 1952 is from a plane-table survey by the New Mexico State Engineer; and that for 1953 is from a reconnaissance based upon the 1952 data. The estimated pumpage was calculated on the basis of a duty of 2.5

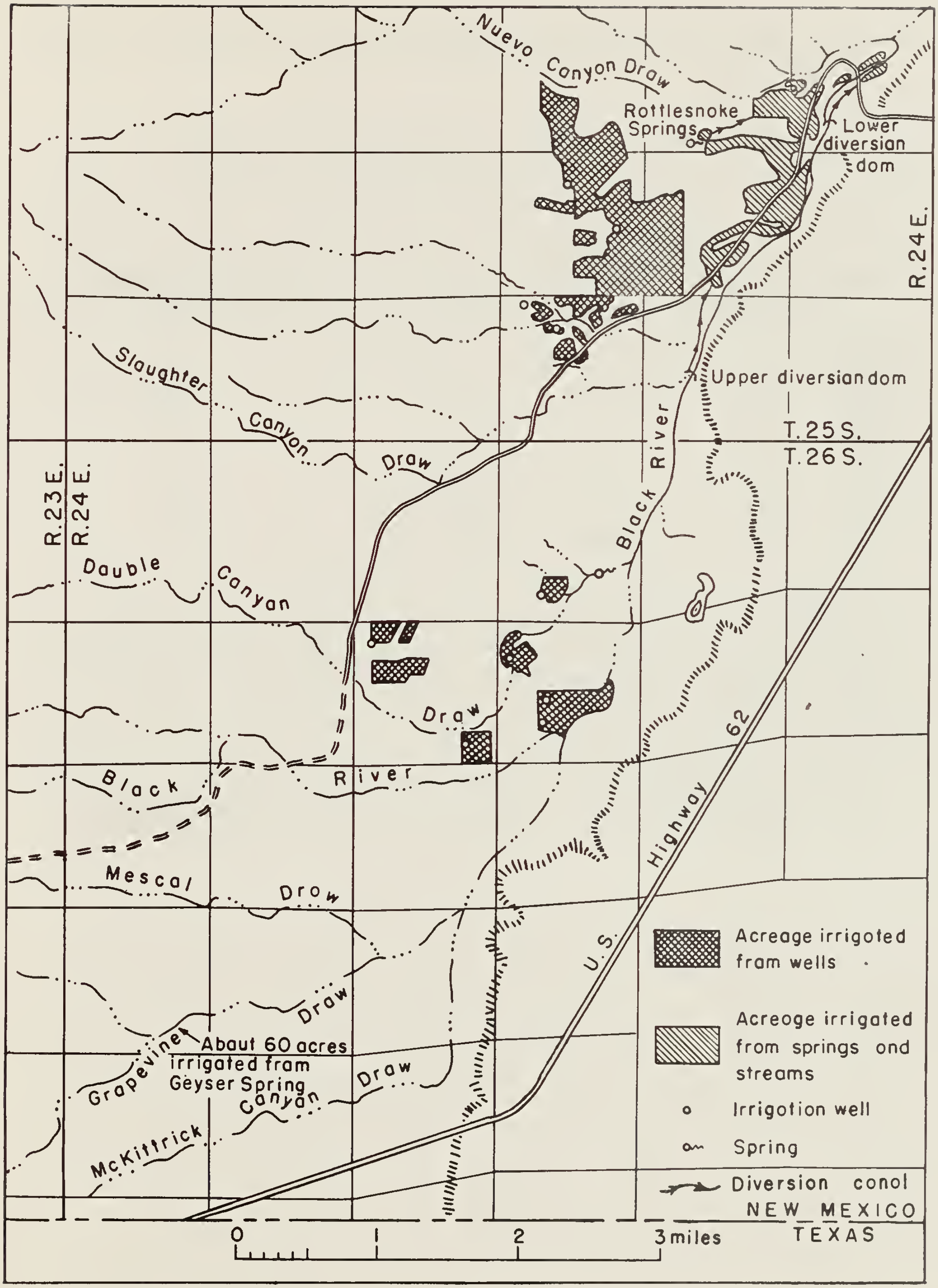

Figure 4.--Irrigated lands in upper Black River valley, Eddy County, N. Mex., 1953.

feet of water for cropland and about 0.5 foot of water for pasture land per season.

Acreage irrigated from wells and estimated pumpage in the upper Black River Valley, by years

Year	Irrigated land		Total (acres)	Estimated pumpage (acre-feet)
	Crop (acres)	Pasture (acres)		
1946	18	0	18	45
1947	18	0	18	45
1948	23	0	23	55
1949	23	0	23	55
1950	50	10	60	130
1951	230	20	250	600
1952	395	275	670	1,100
1953	460	260	720	1,250

Additional lands probably could be irrigated on the relatively wide valley bottom in T. 26 S., R. 24 E., without much leveling of land, if sufficient ground water could be obtained. Additional lands on the alluvial fans near the valley floor in this same township and farther north in the vicinity of Rattlesnake Springs also could be developed without much leveling of land. In all, 2,000 to 3,000 acres probably are susceptible to irrigation in the area upstream from the Highway 62 crossing over the Black River.

GENERAL GEOLOGY

The oldest rocks exposed in the area are those belonging to the limestone facies of the Guadalupe series of Permian age. These rocks crop out in the Guadalupe Mountains along the northwest boundary of the area. Along the reef escarpment the reef talus beds dip steeply to the southeast and terminate in the subsurface where they interfinger with sandstone beds. The limestone and sandstone beds of equivalent age southeast of the escarpment are covered by anhydrite and gypsum beds of the lower part of the Ochoa series, also of Permian age. Above the gypsum beds, the much younger alluvial sediments mantle most of the bedrock in the Black River valley and are confined mostly to that valley and the canyons in the Guadalupe Mountains.

Guadalupe Series

Capitan and Carlsbad Limestones

The massive beds of limestone and partly dolomitic limestone that crop out principally in the walls of canyons cut through the reef escarpment of the Guadalupe Mountains are a part of the Capitan limestone. Along the crest of the mountains near the reef escarpment, the Capitan limestone is overlain by more thinly bedded limestone, dolomitic limestone, and siltstone which is part of the Carlsbad limestone. The Carlsbad limestone thickens to the northwest and at depth it interfingers with the Capitan limestone. These formations, together with deeper lying limestone units not considered in this report, constitute the limestone facies of the Guadalupe series.

The reef talus beds of the Capitan limestone have a steep dip to the southeast and within a very short distance from the reef escarpment dip beneath the surface. These reef talus beds underlie the northwestern part of the Black River valley but probably terminate within a few miles to the southeast of the reef escarpment, where the talus beds interfinger with dominantly sandstone beds of the Bell Canyon formation of equivalent age. The Bell Canyon formation has a general southeastward dip in the Black River valley and in the area to the southeast. The top of the Bell Canyon formation was encountered at a depth of about 400 feet in three oil-test wells in secs. 9 and 10, T. 25 S., R. 24 E., and is encountered at a lower altitude to the south and east of these wells. The Bell Canyon formation and, to the northwest, the Capitan limestone southeast of the reef escarpment are overlain by gypsum and anhydrite of the Castile formation. x 26

Solution of the limestone by ground water in the Capitan and Carlsbad limestones along fractures has resulted in the development

of many large caverns, the most famous of which are the Carlsbad Caverns, but the limestone adjacent to the caverns is commonly very dense and the over-all porosity of the Capitan and Carlsbad limestones may be small. The porosity of the Capitan limestone probably decreases markedly southeast of the reef escarpment where the talus beds are overlain by the anhydrite and gypsum of the Castile formation. Newell and others (1953, p. 208, 209) state:

"The Permian rocks which are now most permeable in the Guadalupe Mountains are marked by a narrow belt of caverns and vesicular dolomite along the posterior margin of the Capitan reef, where calcitic rocks of the Capitan reef are abruptly replaced by dolomites of the Carlsbad facies. The celebrated Carlsbad Caverns and innumerable smaller caverns of the area represent extensive ground-water solution in the belt of highly permeable rocks in the transition zone immediately behind the reef. The localization of high permeability in the zone of horizontal replacement of calcitic reef limestones by backreef dolomites may have resulted from leaching of calcium carbonate inclusions (e.g., shell detritus) in a dolomitic matrix. The reef limestone and reef talus, originally highly permeable, have been sites of extensive enrichment by calcium carbonate, so that the permeability now appears to be quite low."

Ochoa Series

Castile Formation

The Castile formation overlies the Bell Canyon formation and Capitan limestone southeastward from the Guadalupe Mountains and thickens to the southeast. In the eastern part of the area under investigation the Castile formation is overlain by residual materials of the Salado formation and by the Rustler formation. The bulk of the Castile formation is anhydrite. The formation does contain some limestone and sandstone beds and, farther east, salt beds.

Gypsum beds of the Castile formation crop out in the valley of the Black River, particularly in the area between Rattlesnake Springs and Black River village. An almost continuous outcrop of gypsum beds forms the south and east valley walls of the Black River from south of the State line northeastward to Black River village, and gypsum beds are exposed or are very near the surface farther southeast. Those gypsum beds also are mostly a part of the Castile formation.

Solution and other erosion probably have removed much of the Castile formation in this area. The depth to which the anhydrite has been altered to gypsum in the area seems to be between 100 and 200 feet. Many sinkholes and small solution passages exist, the presence of which is revealed by a hollow ring given out as one

walks across many of the gypsum beds. Below the alluvial cover, alteration of the anhydrite to gypsum and solution of gypsum probably also have occurred, but here the channels in gypsum may be filled largely with clay, silt, and sand from the overlying alluvium, materially reducing permeability of the gypsum beds.

Cracks which develop in anhydrite may allow circulation of water. When this occurs, the anhydrite is altered by the addition of water to form gypsum. As the volume of the resulting gypsum is larger than the initial anhydrite, this results in further disruption of the beds which in turn allows more circulation of water. By these means, much of the anhydrite may eventually be converted to gypsum. Inasmuch as the lower part of the Castile formation in this area, even where the formation is thin, is reported to contain anhydrite, it appears that very little circulation of ground water occurs between the alluvium of the Black River valley and the Capitan limestone and Bell Canyon formation underlying the Castile formation.

In places north of Rattlesnake Springs there are exposures of gypsum blocks which have been recemented with gypsum to form a gypsum conglomerate which immediately overlies regularly bedded gypsum. This may represent a gypsum residuum of the Salado formation from which the common salt and some gypsum beds have been leached, as the Salado formation farther east contains much common salt and anhydrite. Blocks of limestone cemented with gypsum also are exposed north of Rattlesnake Springs. These conglomerates are probably remnants of the Rustler formation. These patches are thin and probably of minor extent and for this reason have been included in the Castile formation. Farther east there are more extensive exposures of the Rustler formation, but even there the exposures are small and the formation has not been distinguished from the Castile formation on the geologic map of the area (pl. 1).

Alluvium

The alluvium consists of sand, gravel, conglomerate, clay, and reworked gypsum which extend over most of the valley of Black River. The alluvium ranges in thickness from a featheredge to at least 200 feet. Locally the alluvium fills sinkholes developed in the underlying gypsum beds of the Castile formation.

North of Rattlesnake Canyon and eastward to Highway 62 south of White City, the alluvium occurs primarily as relatively isolated hills less than 50 feet high resting on a rather even bedrock floor of gypsum. To the south, along the Black River, the alluvium is much thicker. Water wells drilled in secs. 26, 27, and 34, T. 25 S., R. 24 E., indicate that the alluvium ranges in thickness from at least 100 feet to more than 165 feet. Farther south in secs. 9 and 10, T. 26 S., R. 24 E., logs of oil-test wells report the top of

the gypsum at depths ranging between 165 and 200 feet. To the west of the oil-test wells and the wells near Rattlesnake Springs, the alluvium in the fans along the mountain front may be somewhat thicker than 200 feet in places. The thickness of the alluvium in the canyons is not known but probably is no greater than 200 feet in some of the larger canyons and more likely about 100 feet.

The sand and gravel in the canyons are commonly very coarse and, though they are poorly sorted, the permeability probably is fairly high. The material near the apexes of the alluvial fans also is poorly sorted; that in the fans probably is best sorted near their toes. The fans, however, contain much more clay than the alluvium in the canyons, and for that reason the sediments in the fans probably are much less permeable than the sediments in the canyons. The conglomerates constitute only a small part of the alluvium, but it is from the conglomerates that the largest yields of water have been obtained in the upper Black River valley. Commonly, the conglomerates are composed of limestone pebbles and boulders cemented by calcium carbonate to form a dense rock. Exposures of conglomerate occur along the Black River downstream from the vicinity of Rattlesnake Springs. Every exposure of the conglomerate is highly fractured, and slump blocks are common. It is reasonable to suppose that these structures exist in parts of the alluvium that are deeply buried. The fracturing and slumping of the conglomerate may be caused by the uneven removal by solution of the underlying gypsum beds, or by the settling of the fill. The conglomerates seem to occur, in part, as fill in buried channels that were cut in the gypsum or older alluvium. In places, after the channels had been filled, the gravels were deposited on the adjacent slopes. Thus some of the conglomerates seem to occur in stringers. This is suggested by the logs of three wells in sec. 27, T. 25 S., R. 24 E., and illustrated in figure 5. Here two cemented gravel beds are separated by clay and hydraulically act as two independent aquifers in this locality. The trend in water levels observed during production tests on some of the wells finished in the conglomerates indicate boundary effects which further suggest stringer deposits.

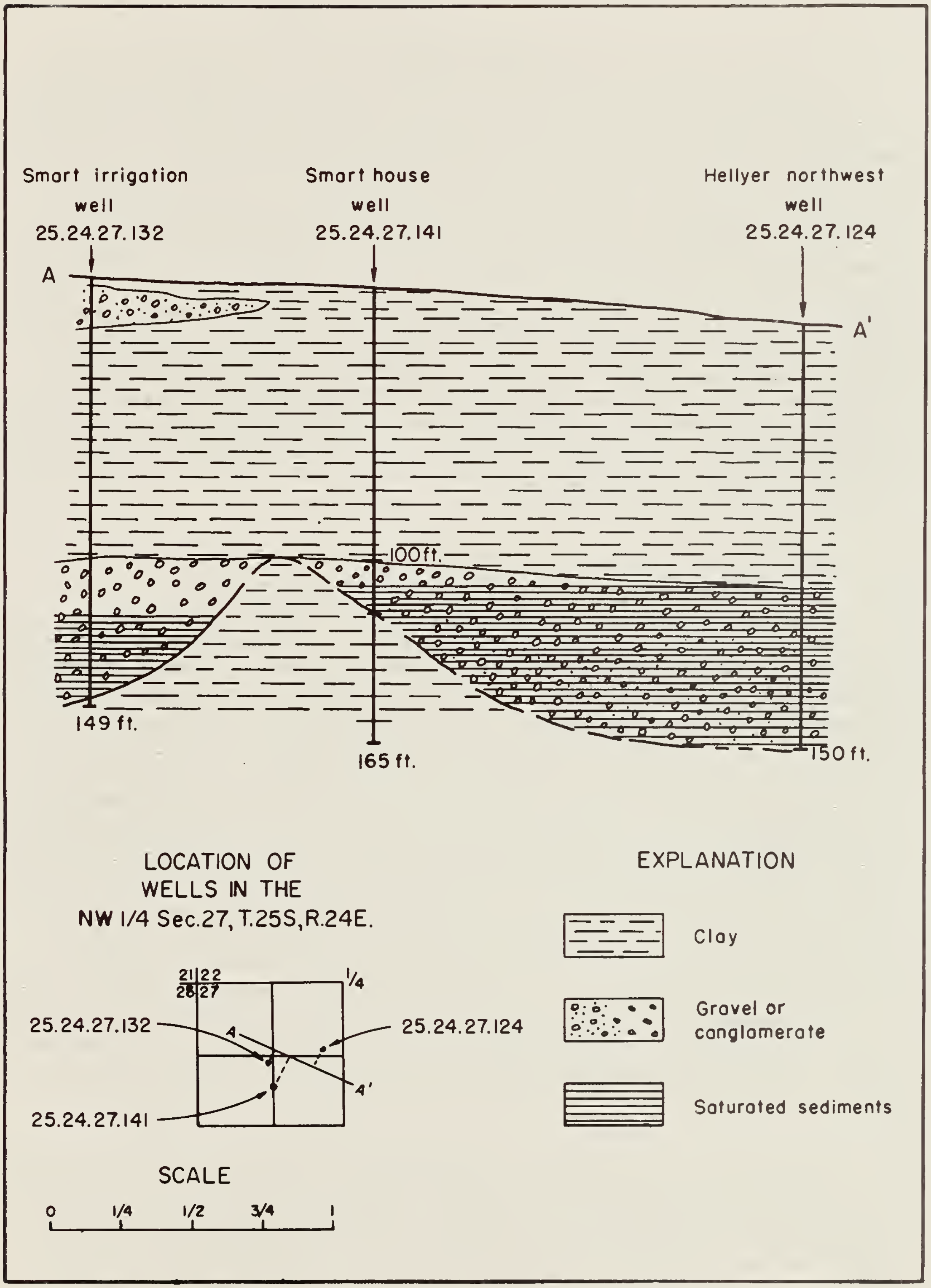

Figure 5.--Inferred relation between aquifers tapped by wells in sec. 27, T. 25 S., R. 24 E., Eddy County, N. Mex. (Based on driller's logs of three wells and results of production tests.)

GROUND WATER

The principal water-bearing formation in the upper Black River valley is the alluvium. Most of the irrigation wells are finished entirely in the alluvium, and even wells drilled below the alluvium obtain most of their water from the alluvium. Further, the large springs in the area issue from the conglomerate and gravel of the alluvium. However, in the valley north of Rattlesnake Springs and downstream to the east where the alluvium is thin, some wells finished in the gypsum beds in the upper part of the Castile formation furnish water for stock. The Capitan and Carlsbad limestones yield water to wells in the Guadalupe Mountains along the northwest border of the area. The relation of the water in the Capitan and Carlsbad limestones and the Castile formation to the water in the alluvium is discussed briefly in the following sections. The discussion deals principally with water in the alluvium and more particularly with the occurrence of water in the alluvium in the vicinity of Rattlesnake Springs.

Capitan and Carlsbad Limestones

Several seeps and small springs occur high on the slopes along Guadalupe Ridge near the reef escarpment. Many of these seeps and springs issue from limestone beds that overlie silt and fine sandstone beds in the Carlsbad limestone. The water from each spring either is lost by evaporation and transpiration or sinks into the next lower limestone bed within a short distance of the spring from which it issues. The springs represent only part of the discharge from perched water-bearing beds. A large part of the perched water probably moves slowly through the partially confining silt and sandstone beds to the next lower perched aquifer, and finally into the massive beds of the Capitan limestone. The general direction of movement of the water in these perched aquifers is northeast, in the general direction of the dip of beds, and downward to the main zone of saturation. Locally, along the reef escarpment, some of the perched water may move to the southeast along the dip of the beds in the Capitan limestone or move laterally into the adjacent fill in the deeper canyons, but there is no evidence of such movement.

The zone of saturation in the limestone near the escarpment is not well defined by the available data. In the Carlsbad Caverns the zone of saturation is no higher than the surface of the unsounded pool in the bottom of the caverns, 1,025 feet below the mouth of the cave and at an altitude of approximately 3,325 feet (Bretz, 1949, p. 449). In that pool the water level is approximately 300 feet below that in the gypsum beds and alluvium in the Black River valley 1.5 miles south of the caverns. A short distance east of the Carlsbad Caverns, the water level in one of the

deep wells at White City in sec. 34, T. 24 S., R. 25 E., is reported to be 800 feet below the land surface and at an altitude of approximately 3,100 feet. In this particular stretch along the reef escarpment, water in the zone of saturation in the Capitan limestone is not moving southeastward through the Castile formation into the alluvium of Black River valley. Farther southwest from the Carlsbad Caverns, the zone of saturation in the Capitan limestone undoubtedly is higher than it is at the caverns, but it probably is still well below the base of the alluvium in the canyons. It thus appears that the water in the zone of saturation in the Capitan limestone does not move southeastward into the upper gypsum beds of the Castile formation or the alluvium of the canyons or fans in the valley of Black River. On the contrary, if there is any hydraulic connection between the limestone and alluvium in Black River valley, water must move downward into the limestone. However, some water from perched aquifers in the limestone may contribute some of the recharge to the aquifers in the gypsum beds and alluvium.

Some of the water in the zone of saturation in the Capitan limestone near the Carlsbad Caverns might move southeastward into the sandstones of the Guadalupe series; but any movement in this direction is probably slow, because salt water is encountered in these sandstone beds generally within a few miles of the reef escarpment, whereas the water in the Capitan limestone is very low in chloride. Farther southwest from the Carlsbad Caverns water in the Capitan limestone may be moving more freely to the east into the sandstones of the Guadalupe series. An oil-test well located in the NW$\frac{1}{4}$ sec. 9, T. 26 S., R. 24 E., that later was converted into an irrigation well, reportedly develops water from the Bell Canyon formation. The well is cased to a reported depth of 450 feet and finished at a depth of 595 feet. The well is pumped at the rate of 1,000 gallons a minute and yields water having a chloride content of 7 parts per million, a sulfate content of 818 parts per million, and a hardness of 1,030 parts per million. Although most of the water may be coming from the Bell Canyon formation in this well, the low chloride content suggests that the water is coming from the alluvium. Further, the temperature of the water pumped, $68\frac{1}{2}^{\circ}$ F., is about the temperature of that pumped by other wells finished in the alluvium. The water level in the finished well in June 1952 agrees within a few feet of the water level measured in the well in April 1952 when the well was being drilled in the alluvium. It is unlikely that the water in the alluvium and that in the underlying Bell Canyon formation would have about the same head unless there was a general connection between the two aquifers, and this does not seem to be the case in the general area.

Castile Formation

In the valley of the Black River where the alluvium is thin

or above the zone of saturation, some water is developed for stock use from wells finished in the gypsum beds of the Castile formation at depths of less than 100 feet. Below this depth the Castile formation is mostly anhydrite, which indicates that no appreciable circulation of ground water has occurred in this part of the section (see p. 17). The water in the gypsum to the north of the Black River moves from near the reef escarpment into the alluvium in the vicinity of the Black River at a gradient of as much as 75 feet per mile in places. South of the Black River also some water moves through the gypsum beds into the alluvium from within a short distance of Black River. Some water probably moves also in a downstream direction through the gypsum beds underlying the alluvium. The water occurs under water-table conditions and is continuous with the water in the alluvium. Water moving through these gypsum beds is very hard and contains 1,200 to 1,500 parts per million of sulfate. The relatively high mineral content distinguishes these waters from those which have moved mostly through the alluvium. Because these waters move into the alluvium, the sulfate content of the water in the alluvium becomes increasingly higher downgradient. Water that enters the Castile formation is derived largely from rainfall in the area, and it is inferred from the small recharge area that the amount of water moving through the Castile formation and into the alluvium is small compared to that which moves almost entirely through aquifers in the alluvium.

Alluvium

The water in the alluvium of the upper Black River valley probably is derived primarily from floodwaters in the larger canyons heading in the Guadalupe Mountains, although, as stated previously, smaller amounts of water move out of the gypsum beds into the alluvium. Some water is derived also from direct precipitation on the alluvium, and probably some water finds its way into the alluvium in the canyons as discharge from perched water-bearing beds in the Capitan and Carlsbad limestones. The water in the alluvium in the mountains moves into the alluvial fans and through them toward the alluvium of the Black River valley where, together with the water in the gypsum beds, it moves in a general northeastward direction down the Black River valley in this area. Plate 1 shows the inferred slope and configuration of the water table in the alluvium and adjacent gypsum beds in the vicinity of the present irrigation wells in upper Black River valley. Water-level information is too meager to reveal the precise direction of movement of water in the alluvium between the crossing of Highway 62 over the Black River in sec. 16, T. 25 S., R. 25 E., and Black River Village.

Large yields of water have been obtained from some of the wells finished in or drilled through various conglomerate beds. Well 25.24.27.124 was pumped at the rate of 1,240 gallons a minute for 9 hours on September 8, 1952, with a resulting drawdown of

10.1 feet. Well 25.24.27.421 had a drawdown of 17.3 feet after being pumped 9 hours at the rate of 1,320 gallons a minute on September 8, 1952. Another well (25.24.34.112a) yielded 450 gallons a minute and had a drawdown of approximately 3 feet. However, in places where the conglomerate is absent, thin, or does not contain fractures, the yields from wells have not been adequate for irrigation purposes.

The chemical quality of the water in the alluvium depends to a large extent on the source of the water. The water moving into the alluvium from adjacent gypsum beds is high in sulfate, whereas water that has moved mostly through alluvium from its source in the canyons is comparatively low in sulfate, as shown in red on plate 1. The wells in the Black River valley in sec. 10, T. 26 S., R. 24 E., yield water high in sulfate, and the water that issues from the headward springs on the Black River in sec. 3, T. 26 S., R. 24 E. is high in sulfate also. Water that moves eastward through the alluvial fans between Rattlesnake Springs and the State line to the south is generally low in sulfate. Irrigation wells 25.24.27.421 and 25.24.34.112a yield water in which the sulfate concentration is about 600 parts per million, which is considerably higher than might be expected if the water moving through the aquifer in this locality had been restricted entirely to the alluvium. It suggests that upgradient the alluvium is thin in places and that water may move for some distance through underlying gypsum beds. Between Rattlesnake Canyon and Walnut Canyon north of Black River, the water is moving toward the Black River largely through gypsum beds and has a concentration of about 1,500 ppm of sulfate. In the alluvium adjacent to the Black River as far east as the crossing of Highway 62 in sec. 16, T. 25 S., R. 25 E., water containing only 530 parts per million of sulfate has been encountered but is probably flanked by more gypsiferous water that moves in from either side through aquifers in gypsum beds.

The dry-weather flow of the Black River and the flow of the various springs in the valley are dependent on the water in the alluvium. Changes in storage of water in the alluvium result in changes in flow of the various springs and Black River. In addition to natural changes in storage caused, in part, by variations in recharge, the storage is now decreased by pumping of the water from wells in the area.

Relation of the Flow in the Upper Perennial Stretch of Black River to Water in the Alluvium

The upper perennial stretch of the Black River between the headward springs in the SE¼ sec. 3, T. 26 S., R. 24 E., and the point of observed maximum flow near the NW¼ sec. 25, T. 25 S., R. 24 E., coincides roughly with a line of gypsum exposures along the right bank of the river. In the SE¼ sec. 26, T. 25 S., R. 24 E.,

exposures of gypsum occur immediately west of the Black River. These conditions suggest that the water moving through the thicker alluvium to the south and west is forced to the surface in the stretch where the apparently less permeable gypsum beds are at or very near the surface. Farther downstream, where exposures of conglomerates and other alluvial material occur in the valley, the alluvium is evidently thicker and more extensive, and the stream begins to lose water, the flow disappearing into sand, gravel, travertine, and conglomerate in the NE$\frac{1}{4}$ sec. 24, T. 25 S., R. 24 E. Some water may move as underflow in the shallow fill below the river, but a larger part of the water probably moves through the thicker alluvium a short distance west of the river in this upper perennial stretch.

The flow of the headward springs of the upper perennial stretch of the Black River appears to have declined from about 1.0 cfs in the latter part of 1953 to about 0.7 cfs in the early part of 1954 (see fig. 3). The decline in flow caused by natural changes in storage probably has not been appreciable during the past year. In wet years, however, the discharge may be far greater than the 1.0 cfs measured in 1953. If the drought conditions persist, the flow of the springs will continue to diminish but at a slow rate. Pumping in the locality probably has had a greater effect on the flow of the headward springs than the drought conditions.

Pumpage from wells that appear to draw their water primarily from the alluvium in secs. 9 and 10, T. 26 S., R. 24 E., south and southwest of the upper perennial stretch of the Black River, amounted to approximately 530 acre-feet in 1953, or a yearly average of about 0.7 cfs. Of this amount an estimated 30 percent of the water might be returned to the ground-water body and the net withdrawal then would be about 0.5 cfs.

The coefficient of transmissibility of the aquifer in the alluvium in this area, based on the yield of the headward springs of about 1 cfs, the gradient of the water table south of the springs of about 25 feet per mile, and a contributing cross-section about 1 mile wide, would appear to be about 25,000 gallons a day per foot. (The coefficient of transmissibility is expressed here as the gallons a day that would be transmitted through a vertical section of the aquifer 1 foot wide under a unit hydraulic gradient or the quantity that would move through a section of the aquifer 1 mile wide under a gradient of 1 foot per mile). The coefficient of storage is assumed to be about 0.2, which is the order of magnitude of the storage coefficient for unconsolidated alluvium under water-table conditions. (The coefficient of storage may be expressed as the volume of water in cubic feet released from storage in a column of the aquifer with a cross-section of 1 square foot when the water level is lowered 1 foot). The effective center of pumping is in the SE$\frac{1}{4}$NE$\frac{1}{4}$ sec. 9, T. 26 S., R. 24 E., about 2,600 feet north of well 26.24.9.441 and about 6,600 feet from the headward springs.

On the basis of the estimated coefficient of transmissibility of 25,000 gallons a day per foot and a coefficient of storage of 0.2, the drawdown at the headward springs would be about 0.26 foot at the end of 2 years of pumping and in well 26.24.9.441 about 1.6 feet at the end of 1953, the second year of pumping from the wells in this area. The water level in well 26.24.9.441 declined about 2.8 feet during the past 2 years (fig. 6). The difference in the observed decline and that estimated to be caused by pumping in the area represents the natural decline in water levels at this well and apparently amounts to 1.2 feet for the two-year period. A natural decline in water levels also has occurred in the water table in the vicinity of the headward springs but the magnitude of the decline is not known. Thus the diminution in the flow of the headward springs is a combination of the natural decline in head and the decline caused by pumping in the area.

Probably more than half of the water pumped in the area in the next few years will be taken from storage in the aquifer, and water levels will continue to decline in this area during this period, but at a decreasing rate. The diminution of the spring flow due to pumping will probably be less than 0.3 cfs during the next few years, but eventually the diminution should approach 0.5 cfs if the pumping rate were to remain about the same as at present.

Diversion of water from the Black River in the upper perennial stretch for use in the irrigation of lands in the vicinity of Rattlesnake Springs is accomplished by means of two diversion dams. The upstream diversion dam, the larger of the two, is in the NW$\frac{1}{4}$ NE$\frac{1}{4}$SW$\frac{1}{4}$ sec. 35, T. 25 S., R. 24 E. Considerable water can be held behind the dam as surface storage, and as ground-water or bank storage. Diversion is by gravity flow through a canal and hence the rate of diversion varies with the level of the pool behind the dam. During the irrigation periods, water is diverted at a rate appreciably greater than the normal flow of the stream. The rate of flow of diverted water near the end of the irrigation season often is considerably less than the rate at the beginning of the season because the level of the pool has declined and not necessarily because of diminution in the natural stream-flow. The other diversion dam, in the NE$\frac{1}{4}$NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 24, T. 25 S., R. 24 E., can hold very little water in storage. The water diverted at this point is essentially the natural flow of the stream and generally ranges between 1 and 3 cfs.

Rattlesnake Springs

Rattlesnake Springs issue as a series of faint boils through the sandy bottom of a small developed pool situated on the flats of Nuevo Canyon Draw in the SW$\frac{1}{4}$ sec. 23, T. 25 S., R. 24 E. (fig. 2). A covered concrete sump has been constructed in the pool from which water is drawn and pumped to the Carlsbad Caverns for domes-

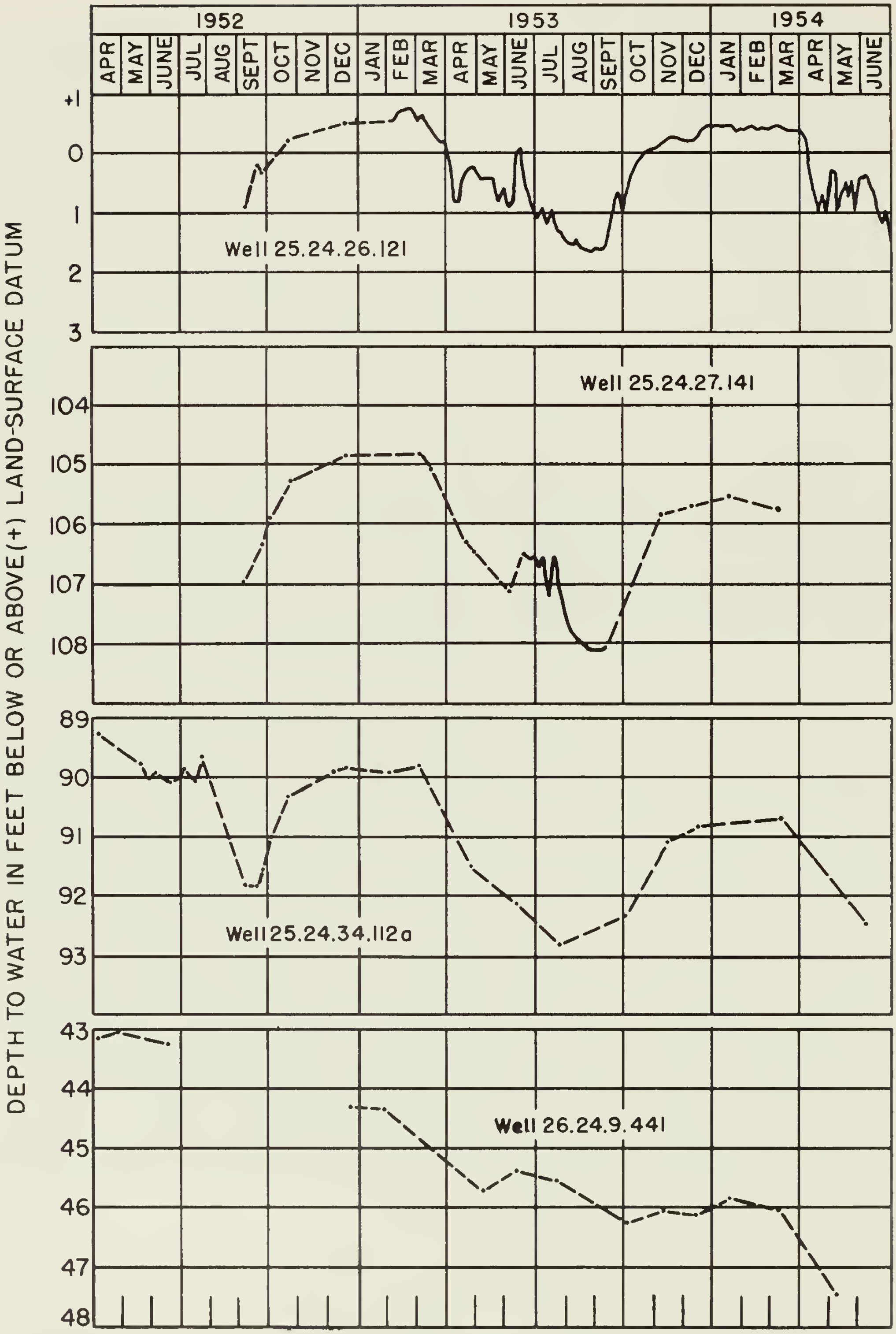

Figure 6.--Hydrographs of selected observation wells in upper Black River valley, Eddy County, N. Mex., 1952-54. (Periodic measurements represented by dots.)

tic use. The National Park Service estimates that 35,000 gallons a day is pumped to the caverns during the summer by the high-pressure pump which operates intermittently at 60 gallons a minute.

The flow of Rattlesnake Springs can be diverted through two ditches known as the north and south ditch for the irrigation of nearby lands, or the water can be discharged out the east or main outlet down the natural channel where it can be ponded behind small dams constructed across the channel or allowed to flow on eastward to the Black River (fig. 7). The flow can be controlled temporarily by adjusting the size of the openings of the submerged slide head-gates at the various outlets, but the long-period flow is the natural flow of the springs. The pool surface usually fluctuates a foot or more in response to the control by the gate openings, but the average altitude of the pool surface is about 3,635 feet, about 0.5 foot below that of the encircling stone wall. Periodic measurement of the discharge from Rattlesnake Springs at monthly intervals was begun in April 1952. The discharge is measured under conditions as they exist at the time of the regular visit; that is, the discharge may be measured in any one or both of the ditches and main outlet within 50 feet of the pool. The stage and flow of the springs are allowed to stabilize for several hours prior to measurement of the discharge, but the stage of the pool at time of measurement of the spring flow has differed somewhat from month to month. If complete stabilization is reached, the flow at any stage would be the actual flow from the springs. Thus, although the discharge measurements of the springs were not made from month to month with the same pool stage and the discharges therefore are not strictly comparable, the error caused by the difference in stage probably is not very large. From April 1952 to June 1954, the observed flow of the springs has varied between 1.7 and 4.2 cfs. The flow is at a minimum during the irrigation season and largest during the late winter and early spring (see table 4 and fig. 3). In general, the stage of the pool is somewhat higher in the winter and spring than at other times of the year.

The mineral content of the water issuing from the springs is about the lowest existing in the area (see table 3 and pl. 1). The water has a bicarbonate content of about 290 parts per million, a sulfate content of 120 parts per million, and a chloride content of 6 parts per million. Several partial analyses made of the spring waters at different times indicate no significant change in the quality of the water in the past few years.

<u>Source of the Springs</u>.--The water that issues from Rattlesnake Springs discharges from a conglomerate through overlying sand and gravel and into the spring pool. In the area around the springs in Nuevo Canyon Draw the conglomerate is overlain by silt and clay and the water in the conglomerate is under slight artesian pressure. This particular conglomerate may be

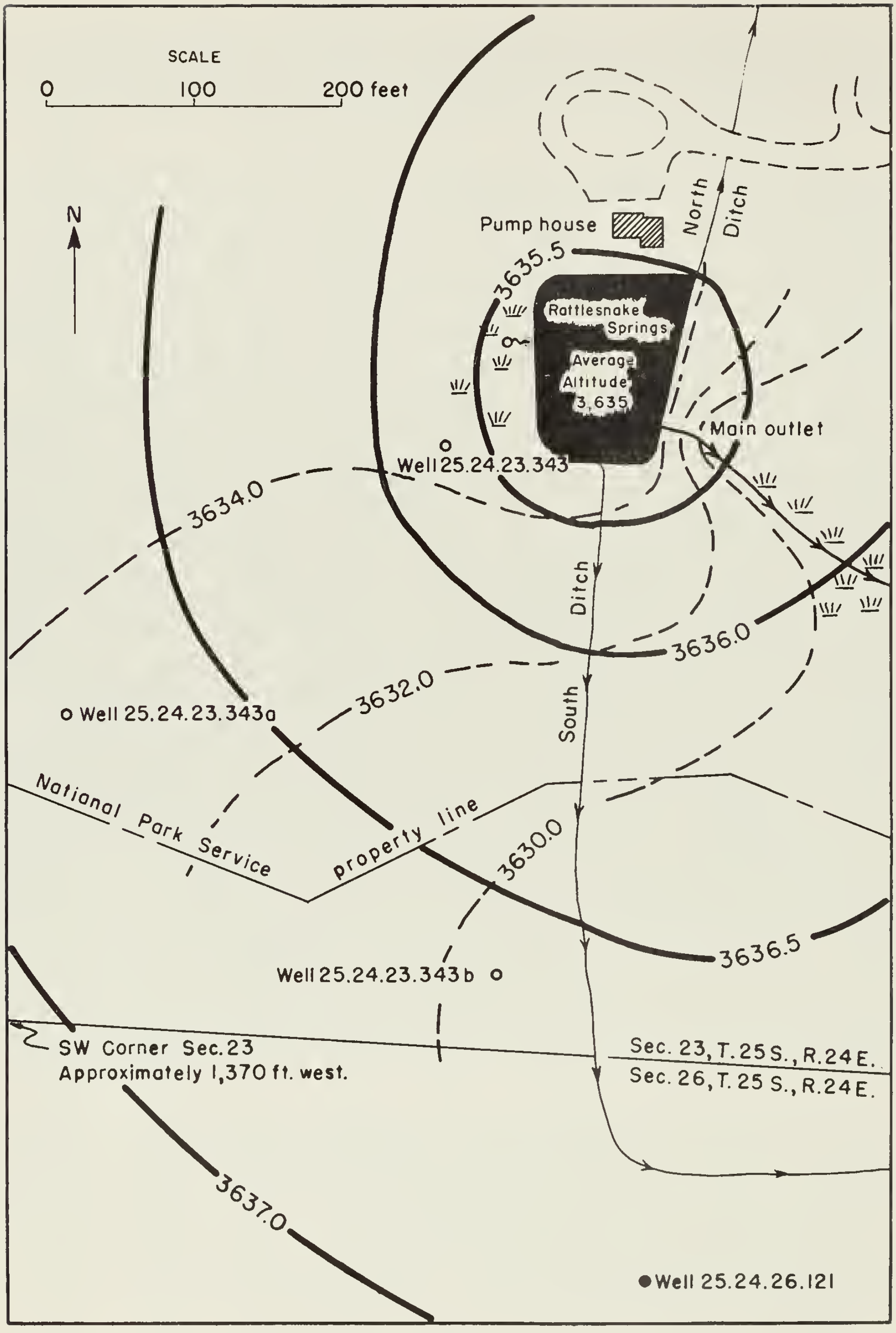

Figure 7.--Altitude and configuration of the piezometric surface (solid line contours) of the conglomerate aquifer and the water table (dashed contours) in the silts in the vicinity of Rattlesnake Springs, Eddy County, N. Mex. (Wells in silt, open circles; well in conglomerate, solid circle.)

cut off to the northeast and abut against clays; at least, the movement of water is so restricted by some means that most of the water in the aquifer to the west discharges at Rattlesnake Springs. A small volume of the water from the springs moves from the pool into the adjacent silts, as shown by the altitude of the water level in a few shallow observation wells finished in the silts. The inferred altitude and configuration of the piezometric surface of the water in the conglomerate and the water table in the silts in the vicinity of Rattlesnake Springs are illustrated in figure 7.

About 550 feet south of Rattlesnake Springs, well 25.24.26.121, which was dug and blasted into the conglomerate, taps the same aquifer as the springs. Detailed fluctuations of water level were obtained from a recording gage installed on this well. The water level is, in general, about 1 foot above the level of the pool at Rattlesnake Springs, and fluctuates in phase with the pool level. However, the water level in this well also fluctuates in phase with the discharge from the springs at constant pool level; that is, the elevation of the water level in the well lowers with respect to the pool level as the discharge from the springs decreases. This relation is illustrated as a graph in figure 8. The altitude of land-surface datum at this well is 3,636.4 feet.

The departure of individual control points from the straight line in figure 8 is caused mostly by the difference in the stage of the pool of Rattlesnake Springs from measurement to measurement and hence in the water level in the well. A straight line relation between the change in water level in the well and the discharge of the pool should hold for all discharge rates. Using the graph, the inferred water level in well 25.24.26.121 at a time when no flow would occur from Rattlesnake Springs at a pool stage of 3,635 feet above sea level would be more than 1 foot below the pool level. If the water level in well 25.24.26.121 under conditions of no flow from Rattlesnake Springs were below the pool level, it would imply that water may be leaking from the conglomerate aquifer through well 25.24.26.121 into the overlying silts, resulting in a lower head, or that some of the water in the conglomerate is bypassing Rattlesnake Springs. If the pool of Rattlesnake Springs were maintained at a constant elevation, apparently a fairly accurate rating curve based on the elevation of the water level in well 25.24.26.121 could be developed for the flow of the springs and could be used to determine this flow at times when discharge measurements were not made.

The source of the water in the conglomerate discharging water at Rattlesnake Springs must be from the direction of higher head and the principal source must furnish water of good chemical quality. The source is inferred from three types of data - namely, the quality of the water, the altitude of water levels in nearby wells with respect to the springs, and the fluctuations in the discharge of Rattlesnake Springs in relation to the pumping of nearby wells.

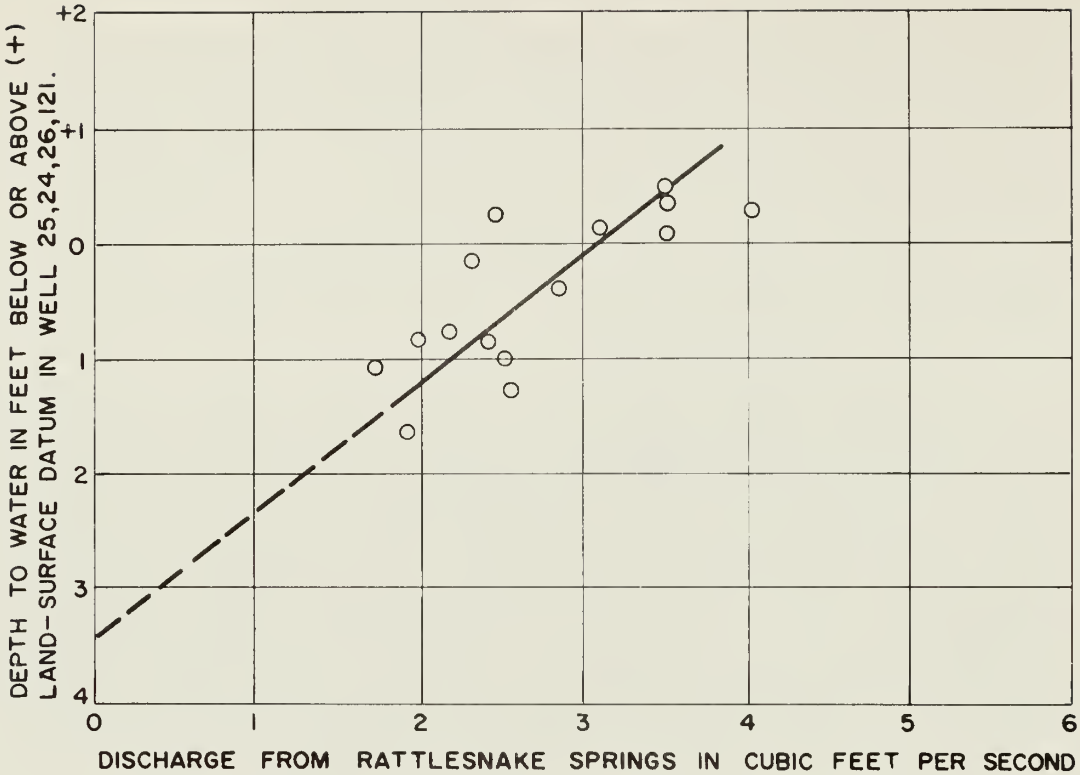

Figure 8.--Relation between stage of well 25.24.26.121 and the flow of Rattlesnake Springs, Eddy County, N. Mex.

In general, altitudes of water levels in wells in the alluvium and gypsum beds to the south, west, and north of the springs are higher than the pool of Rattlesnake Springs, and to the east and northeast are lower; consequently, the water could be derived from the north, west, or south of Rattlesnake Springs. To the north and northwest of the springs, beyond Rattlesnake Canyon, the fill is thin and shallow water occurs only in the gypsum beds which contain water having a sulfate concentration of more than 1,000 parts per million. To the south along Black River, the alluvial fill also contains water high in sulfate. The concentration of sulfate in the water pumped from wells 25.24.27.421 and 25.24.34.112, to the southwest of Rattlesnake Springs, was 621 and 565 parts per million, respectively, which is considerably more than the concentration of sulfate in the spring water. Northwest of these wells and west southwest from the springs, well 25.24.27.124 yields water in which the concentration of sulfate is 39 parts per million, which is considerably lower than that in the spring water. A water sample bailed from the unused well 25.24.27.132 contained 144 parts per million of sulfate. Only to the west and southwest of the springs, therefore, has water of moderate to low concentration of sulfate been found. Thus, on the basis of quality-of-water data, the water emerging from the springs would appear to be derived from the area west to southwest of Rattlesnake Springs.

Well 25.24.26.121, 550 feet south of the springs, fluctuates in phase with the stage of the spring pool, and the spring flow also correlates with the general trend in water levels in this well as observed from a continuous record of water-level stage obtained by a recording gage. About 1 mile west-southwest from this well, detailed fluctuations of water level were obtained by means of a recording gage on unused well 25.24.27.141. Large fluctuations of water level in this latter well are caused by pumping of irrigation well 25.24.27.124 about 1,150 feet to the northeast. Pumping of irrigation well 25.24.27.421, about 3,000 feet east and somewhat south of well 25.24.27.141, also causes minor fluctuations in the two observation wells (25.24.26.121 and 25.24.27.141), but the effect is masked when well 25.24.27.124 is being pumped. The trend in water level in well 25.24.27.141 parallels the trend of the water level in the well near the springs. Figure 9 shows a plot of the daily fluctuation of water level in wells 25.24.26.121 and 25.24.27.141 for July, August, and a part of September 1953. During the period from July 16 to July 20, when irrigation well 25.24.27.124 was idle, the water levels rose in the two observation wells. It thus seems that irrigation well 25.24.27.124 taps the same aquifer as that discharging water to Rattlesnake Springs, and that the water-bearing bed in which well 25.24.27.421 is finished is also a part of the same aquifer system. Parts of this aquifer system probably have only a limited connection with other parts because of the stringer-like occurrence of the conglomerates, as mentioned in the section describing the geology of the area.

About 0.7 mile southwest of well 25.24.27.421, irrigation wells 25.24.34.112a and 25.24.34.124 pump water of about the same quality as that from well 25.24.27.421. Further, the pattern and magnitude of the water-level fluctuations in these wells and the observation well 25.24.27.141 are similar. It is inferred that pumping of these two irrigation wells, 25.24.34.112a and 25.24.34.124, also will have some effect on the flow of Rattlesnake Springs, even though in a 12-hour test the pumping of nearby wells 25.24.27.124 and 25.24.27.421, produced no observable effect on the water level in these two wells.

Well 25.24.27.132, drilled for irrigation purposes but presently not in use, is about 1,100 feet west of the large producing well 25.24.27.124. Well 25.24.27.132 is reported, when tested in 1952, to have been pumped at 1,200 gallons a minute with no detectable drawdown as measured by an airgage. However, in a test made in 1954, it is reported that the well was pumped dry in a very short time, suggesting that the well has become almost completely sealed off from the aquifer in which it was finished. Although the water level in the well probably does not reflect detailed fluctuations of water level in the aquifer, and so is not an ideal observation well, the general trend of water levels in it are instructive.

The water level in well 25.24.27.132 declined very slowly during the period of observation from an altitude of 3,635.1 feet

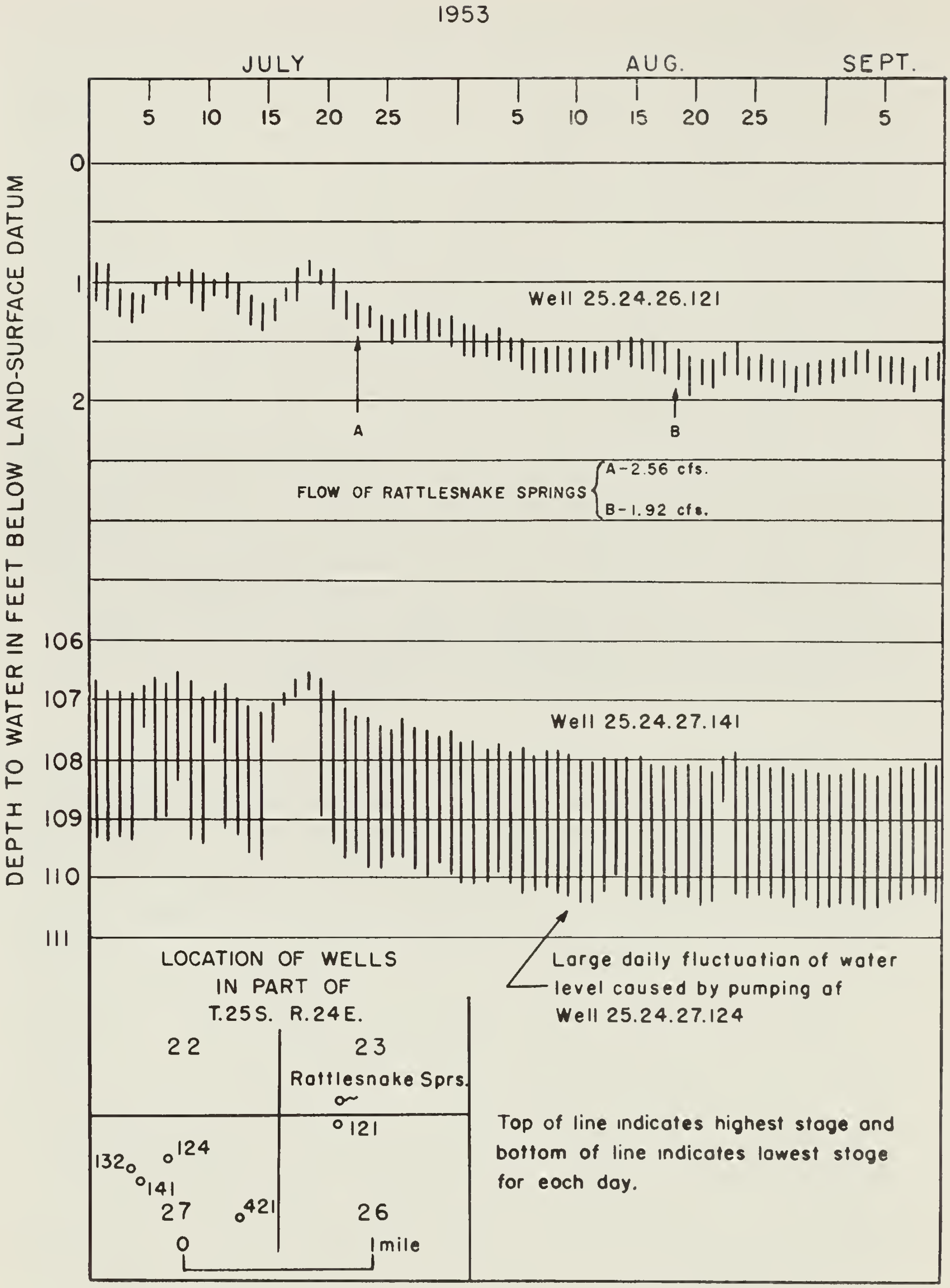

Figure 9.--Relation of daily fluctuation of water level in wells 25.24.26.121 and 25.24.27.141 during July, August, and part of September 1953, Eddy County, N. Mex.

in April 1952 to an altitude of 3,634.6 feet in January 1954. The altitude of the water level on February 1, 1953, was 3,634.9 feet. On the same date, the altitude of the water level in well 25.24.27.124 to the east was 3,642.0 feet, more than 7 feet higher. In well 25.24.26.121 south of Rattlesnake Springs, the water level on February 1, 1953, was at an altitude of 3,636.9, about 2 feet above that of well 25.24.27.132, and the water level in the pool of Rattlesnake Springs was at an altitude of 3,635.2 feet. Pumping of the nearby well to the east (25.24.27.124) has caused no detectable fluctuation of water level in well 25.24.27.132. This suggests that the aquifer tapped by well 25.24.27.132 is independent of, or poorly connected with, the aquifer that discharges water to Rattlesnake Springs. Water in this aquifer probably moves to the northeast, between Rattlesnake Canyon and Rattlesnake Springs.

Effect of Pumping of Nearby Wells on the Flow of Rattlesnake Springs.-- During the 1953 irrigation season from April through part of September, three irrigation wells were in use which draw their water from the aquifer discharging water at Rattlesnake Springs. These wells, 25.24.27.124, 25.24.27.421, and 25.24.34.112a, were pumped, respectively, at 1,240, 1,320, and 450 gallons a minute for an average of about 10.5 hours a day and for an estimated 110 days during the irrigation season. The daily pumping rate of these three wells is about 3.2 cfs, not much less than the winter flow of Rattlesnake Springs. Based on the measured pumping rate and the estimated time pumped, production from these wells was about 700 acre-feet of water between April and September 1953. Assuming a return of 30 percent of the water, the net depletion of the water supply would be about 500 acre-feet during the irrigation season. However, the returned water probably moves toward the river at a shallow depth and does not reach the underlying conglomerate from which the water was pumped, as the conglomerate is overlain by clays having appreciable thickness in this locality.

The discharge from Rattlesnake Springs in March 1953 was 4.0 cfs. By the end of the irrigation season the flow was 1.9 cfs, a difference of 2.1 cfs. Referring to figure 3, if it is assumed that the flow of the springs recovers from pumping effects from year to year, the average flow during the irrigation season might have been approximately 3.8 cfs if no wells had been pumped. However, during the period from April through the middle of November 1953, the average flow appears to have been about 2.5 cfs. This difference of 1.3 cfs for this period amounts to 600 acre-feet and compares reasonably well with the estimated amount of water pumped from wells in the locality. After the close of the irrigation season each year, water levels rise in the area and the discharge of the springs increases and approaches the discharge of the previous winter period. Thus, pumping of the nearby irrigation wells seems to have a definite effect on the flow of the springs. As the discharge from the wells seems to be offset largely by a comparable

decrease in the flow of the springs, there should be no appreciable net lowering of water levels in this aquifer from season to season caused by pumping of wells if the volume of water pumped annually remains approximately constant and less than the spring discharge.

Under present conditions of withdrawal, therefore, any persistent change from year to year in the flow of Rattlesnake Springs and water levels in the aquifer tapped by the wells probably would be related more closely to the recharge of the aquifer rather than to withdrawals for irrigation. As precipitation and probably intensity of rainfall have been less than normal in the past few years, the decrease in the flow of the springs of about 0.5 cfs and the decline in water level of about 0.7 foot from March 1953 to March 1954 (figs. 3 and 6) in the vicinity of Rattlesnake Springs probably were caused by deficient recharge.

If the present irrigation wells in the locality were pumped continuously at their present capacities for most of the irrigation season, the spring flow would be reduced appreciably within a few days of the start of pumping and Rattlesnake Springs might be expected to cease flowing in the latter part of the irrigation season. If the pumpage exceeded the spring flow (plus any water that might be salvaged from evaportranspiration in the spring area as a result of lowered water levels), the water levels in nearby wells probably would show net annual declines.

Should the springs cease flowing, shallow wells might be drilled in the spring area to tap the conglomerate. Ample water probably could be obtained for use at the caverns and possibly for irrigation use to take the place of the spring flow. The pumping of any wells drilled in the immediate vicinity of the springs before the spring flow ceased, however, could be expected to decrease the spring flow by the amount of water pumped.

The water issuing from the springs is more highly mineralized than that pumped from well 25.24.27.124 but of better quality than that pumped from wells 25.24.27.421 and 25.24.34.112a. Assuming that the water discharged from the springs represents a mixture of water of these two types, the bulk of the spring discharge is made up of the water having the better quality. Because approximately half the water pumped in the locality is obtained from the aquifer at the point where it yields the more highly mineralized water, the proportion of the water of better quality issuing at the springs might be expected to increase, and the over-all quality to improve, in time. Further, the small amount of the more highly mineralized water required to give the springs the observed sulfate content suggests that some of the more highly mineralized water in the aquifer is bypassing the springs and, if so, it must move northeastward to the east of the springs.

Blue Spring

Blue Spring issues as a series of large boils between broken and slumped blocks of conglomerate. From the point of issue of the spring water in the NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 33, T. 24 S., R. 26 E., to its junction with a more pronounced drainageway a few hundred yards downstream, the stream channel apparently has been developed in an older channel once filled with a conglomerate. The discharge of Blue Spring has been measured at monthly intervals since October 1952 at a point about 1 mile east of the spring area and above any diversions from Blue Spring Creek. During the period from October 1952 to June 1954, the observed flow has ranged from 10.8 to 13.8 cfs (see fig. 3). The fluctuation of the flow has shown no definite cyclic pattern during the short period of observation. The quality of water issuing from the spring is fair compared with the quality of that obtained in some of the stock wells to the west. The water has a bicarbonate content of 240 parts per million, a sulfate content of 580 parts per million, and a chloride content of 10 parts per million. The temperature of the water at the spring is 66° F.

The source of the water issuing from Blue Spring is not definitely known from the data available, but these data suggest possible sources and eliminate others from further consideration.

The temperature of the spring water is essentially the same as that of water pumped from shallow wells in the locality and thus eliminates any deep-seated source for the spring in the immediate locality. The quality of the water also is better than that which might be expected from deep sources at this site. It therefore appears that the water issuing at the spring is moving through the alluvium and possibly to some extent in the gypsum in the upper part of the adjacent Castile formation. However, the quality of the water suggests that the water has moved mostly through the alluvium.

The magnitude of the discharge from the spring rules out local recharge to the aquifer and suggests recharge over a much larger area such as the upper Black River valley and the canyons in the Guadalupe Mountains. Further, the dry-weather flow in the Black River above the junction with Blue Spring Creek is less than 0.5 cfs, far less than the flow in the perennial stretch of the Black River near Rattlesnake Springs and that of Rattlesnake Springs farther upstream. Blue Spring could be the discharge point for those waters, but additional water is required to make up the observed flow at Blue Spring.

Although there are areas of alluvium of unknown thickness to the north and northwest of Blue Spring, the many exposures of gypsum in that locality suggest that the alluvium is thin, and although a large volume of water could move a short distance through a large solution channel in the gypsum without acquiring a high sulfate

concentration, it seems more likely that the source of the water of Blue Spring is the alluvium to the southwest, up the valley of the Black River. Assuming that the average discharge from Blue Spring of approximately 12 cfs represents the entire discharge of ground water from the upper Black River valley, some inferences as to the amount of water moving through various parts of the alluvium upstream from Blue Spring can be made.

Between Blue Spring and the highway crossing over Black River, about 7 miles southwest of the spring, the few stock wells in that area yield water having a sulfate content of about 1,500 parts per million. It is apparent that these wells are not situated in that part of the alluvium having the water of better quality, but this high-sulfate water probably is contributing a small part of the flow of Blue Spring. Well 25.25.16.141 near the highway crossing over Black River yields water containing 530 parts per million of sulfate from the alluvium. Inasmuch as the contour map (pl. 1) suggests that water in the alluvium and gypsum beds in the Black River valley above the highway crossing seems to converge and flow through the alluvium at the highway crossing, the water from well 25.25.16.141 may represent the average quality of water moving through the alluvium in the valley at the highway crossing. On the basis of the quality of the water in that well, and that of the water of Blue Spring, it is estimated that less than 1 cfs of the high-sulfate water in the intervening area could be added to the water moving through the alluvium at the highway crossing to yield the quality of water issuing at Blue Spring. This would mean that about 11 cfs moves through the alluvium at the Highway 62 crossing over the Black River. At the highway crossing, the saturated part of the alluvium is about 0.25 mile wide and probably less than 50 feet thick. With a water-table gradient of 45 feet to the mile (determined from the contours in pl. 1), the alluvium would need to have a coefficient of transmissibility of the order of 600,000 gallons a day per foot. This is a very high value and suggests the occurrence of water in channels in a conglomerate rather than in uniformly permeable gravel or sand. A network of passageways in a conglomerate would not need to have a very large cross section to transmit 11 cfs under the prevailing hydraulic gradient.

Of the 11 cfs possibly moving through the alluvium at the highway crossing over the Black River, about 4.5 cfs can be accounted for in the loss of visible flow in the upper perennial stretch of the Black River and Rattlesnake Springs. Rattlesnake Springs has an average flow of about 3 cfs which, together with the small amount of unmeasured discharge that enters the silts around the pool and allowing for some loss by evapotranspiration, might amount to a net recharge to the alluvium downstream of approximately 2.5 cfs. The discharge of the Black River in the upper perennial stretch, at the point where the maximum dry weather flow occurs, is approximately 2.0 cfs. The underflow in this reach of the Black River and in the thicker alluvium immedi-

ately west of the stream might amount to an additional 0.5 cfs. The total volume of water of the quality similar to that in the upper stretch of the Black River thus may be as much as 2.5 cfs. During the period from September 1953 through July 1954, eight water samples were collected at 1- to 3-month intervals from the Black River above the lower diversion dam. The sulfate content of the water ranged between 1,170 and 1,320 ppm and averaged approximately 1,250 ppm. Commingling of 2.5 cfs of water from Rattlesnake Springs, which has a sulfate concentration of 120 parts per million, and 2.5 cfs of Black River water, which has a sulfate concentration of 1,250 ppm, would give an estimated sulfate concentration of about 700 parts per million, which is higher than that occurring in the alluvium at the highway crossing. The difference between the estimated flow in the alluvium at the highway crossing of 11 cfs, and the contribution from Rattlesnake Springs and the upper perennial stretch of the Black River and adjacent alluvium of about 5 cfs, is about 6 cfs. Thus about 6 cfs of ground water from sources other than that supplying water to Rattlesnake Springs and the alluvium adjacent to the upper perennial stretch of the Black River is inferred to be moving down the valley of the Black River. The sulfate content of the mixture of water of 6 cfs from these other sources would be about 380 parts per million.

A part of this unaccounted-for flow of 6 cfs must move toward the Black River through the gypsum beds in the area north of Rattlesnake Canyon and west of Highway 62. The water in this area has a sulfate content of approximately 1,500 parts per million, but the amount of water is small, possibly 0.5 cfs. Also, water with a sulfate concentration of 140 parts per million would move between Rattlesnake Canyon and Rattlesnake Springs through the alluvium independently of that issuing at Rattlesnake Springs (see p.33). To the south of Rattlesnake Springs, part of the water in the aquifer tapped by wells 25.24.27.421 and 25.24.34.112a and which has a sulfate content of 650 parts per million may be bypassing Rattlesnake Springs. If water from the three different sources is assumed to contribute a total of 6 cfs of the water moving through the alluvium at the highway crossing over the Black River, then approximately 4.0 cfs must be contributed by the aquifer between Rattlesnake Canyon and Rattlesnake Springs and about 1.5 cfs must move through the alluvium south of Rattlesnake Springs, bypassing those springs.

In summary, on the basis of the above assumptions, data, and calculations, it is concluded that about 4.5 cfs of the water issuing at Blue Spring could be contributed by the surface flow lost to the alluvium in the upper perennial stretch of the Black River and Rattlesnake Springs, about 0.5 cfs from the underflow of the Black River in this stretch and the alluvium immediately west of the river, about 1.5 cfs from water moving through the alluvium immediately south of Rattlesnake Springs and bypassing the springs, about 4 cfs from the alluvium between Rattlesnake Springs and Rattlesnake Canyon

to the north, and about 1.5 cfs in the gypsum beds between Rattlesnake Canyon and Blue Spring.

The calculated quantities of water moving through the alluvium at various places in the upper Black River valley, based on the quality of the water and the observed surface flow, cannot be relied upon at present with much assurance. They merely serve as a general indication of the sources of water in the alluvium. As additional data are acquired, the interpretation of the source of the water issuing at Blue Spring may be altered somewhat, but it seems likely that at least the visible flow in the upper Black River valley that seeps into the alluvium is being discharged at Blue Spring. A decrease in the amount of surface water seeping into the alluvium in upper Black River valley caused by increased diversion for irrigation or by a decrease of the spring flow in the Black River or Rattlesnake Springs may be expected to decrease the flow of Blue Spring in time. The net diminution in the ground-water supply caused by pumping of irrigation wells in the upper Black River valley in 1953 was on the order of 1 cfs. The change in the supply of ground water caused by changes, if any, in the diversion of surface water in the area in the past few years is not known. If the water in the alluvium between Blue Spring and the highway crossing over the Black River occurs under water-table conditions and is moving in rather open channels in a conglomerate, a decrease in the volume of water moving through the alluvium in the upper Black River valley might be reflected by a smaller discharge at Blue Spring within a few months' time. If, however, the water is under artesian conditions in this stretch (which is not likely) or the water moves through a much wider cross section of lower permeability, the effect of a decrease in movement of water in the upper Black River valley may not cause a measurable change in the flow of Blue Spring for several years.

CONCLUSIONS

1. Rattlesnake Springs represent the discharge from an aquifer in the alluvium whose source is considered to be southwest of the springs. Three presently used irrigation wells tap this aquifer and the pumping of these wells has a definite effect on the spring flow. Increased use of these irrigation wells and withdrawals from any new wells in the same locality as these existing wells will result in a further decline in the flow of Rattlesnake Springs.

Although there was a net decline in the spring flow between March 1953 and March 1954, that decline probably was caused mostly by decreased recharge to the aquifer resulting from below-normal precipitation rather than incomplete recovery from the effects of the pumping of wells in the irrigation season.

If Rattlesnake Springs should cease to flow as a result of large diversions from the aquifer, a shallow well probably could be drilled to the conglomerate that could supply the needs of the Carlsbad Caverns. An additional well or two also might take the place of the flow of the springs now used to irrigate lands in the locality. Any such wells drilled in the spring area before the springs ceased flowing would certainly decrease the flow or completely dry up the springs. If the springs dry up, water levels in the area probably would begin to show a net decline from year to year, as water would be drawn from storage within the aquifer.

2. Blue Spring probably is the principal discharge point for the water in the alluvium and upper gypsum beds of the Castile formation in the part of the Black River valley west of Blue Spring. If water moving down the Black River valley between the highway crossing over the river and Blue Spring occurs mainly under water-table conditions and in a few channels in conglomerate, then a change in the flow of water in the alluvium in the vicinity of the highway crossing might be reflected in a change in the flow of Blue Spring within a few months.

If present withdrawal of water by wells from the alluvium in the upper Black River valley is maintained at about 1 cfs annually, the average discharge from Blue Spring may be expected eventually to decline by about 1 cfs owing to this pumping. The seasonal variation in the flow may be greater and, owing to the lag in the effects from the upper valley, the discharge from Blue Spring may reach a minimum after the close of the irrigation season. A change in the use of surface water from the upper perennial stretch of the Black River and from Rattlesnake Springs also eventually would

result in a change in the flow of Blue Spring. Inasmuch as the amount of surface water diverted for irrigation from these two sources is not known, the fluctuation in the flow of Blue Spring caused by this diversion of water is not known and a detailed interpretation of variations in the flow of Blue Spring is not possible at this time.

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TABLES

Table 1

Records of wells in upper Black River valley, Eddy County, N. Mex.

1. Location number designates well and its location. (See page 6 for explanation of well-numbering system.
2. Reported depths are given to the nearest foot, measured depths are given to nearest 0.1 foot.
3. Symbols for use: D, domestic; I, irrigation; U, unused; O, observation; S, stock.
4. R, reported yields. Yield given is that normally pumped.
5. Symbols for method of lift: ET, electric motor driven turbine; GT, gas motor-driven turbine; J, jet; N, none; W, windmill.
6. Altitudes determined by instrumental leveling are given to nearest 0.1 foot. Other altitudes determined by aneroid or estimated from topographic map are given to nearest foot above sea level.

Location number (1)	Name or owner	Depth of well (ft.) (2)	Diameter (in.)	Principal aquifer	Use (3)	Yield (gpm) (4)	Method of lift (5)	Year completed	Altitude of land surface (ft.) (6)	Water Level: Below land surface (ft.)	Water Level: Date of measurement	Measuring point: Description	Measuring point: Distance above land-surface datum (ft.)
24.26.32.123	Wm. Foley	200	8	Alluvium	D,S	-	W	-	3,435	109.4	Dec. 1, 1948	Top of wood block	0.5
25.23.34.444	Anna Colwell	130	6	do.	S	-	W	-	4,160	129.3	Jan. 19,1948	Top of casing	2.35
25.24.11.211	-	46.0	6	Castile (?) formation	S	2	W	-	3,763	29.9	June 8, 1952	Top of casing	.3
25.24.16.410	-	-	6	Alluvium	S	-	W	-	3,800	55.5	May 16, 1952	do.	1.0
25.24.19.421	-	-	10	do.	S	-	W	-	3,950	127.8	May 16, 1952	do.	1.2
25.24.23.343	National Park Service	3.5	4	Alluvium (sand & gravel)	O	-	N	1952	3,635.5	1.1	Mar. 5, 1953	do.	.4
25.24.23.343a	Do.	18.0	4	Alluvium (silt)	O	-	N	1952	3,638.3	4.9	Mar. 5, 1953	do.	1.6
25.24.23.343b	Do.	7.5	4	do.	O	-	N	1952	3,634.8	5.2	Mar. 5, 1953	do.	1.9
25.24.26.121	State Dept. of Game and Fish	15.4	24	Alluvium (conglomerate)	U	-	N	-	3,636.4	+.5	Mar. 5, 1953	do.	3.0
25.24.26.334	McClure and Hellyer	-	-	Alluvium (?)	S	2	W	-	3,674	36.5	Mar. 5, 1953	Top of concrete base	1.1
25.24.27.124	Do.	150	-	Alluvium (conglomerate)	I	1,240	ET	-	3,738.5	94.6	Mar. 5, 1953	Base of timber pump base	.4
25.24.27.132	George Smart	137.0	10	do.	U	1,200R	N	1952	3,753.2	118.3	Mar. 5, 1953	Top of casing	.9
25.24.27.141	Do.	165	22	do.	U	120R	N	1952	3,749.3	104.8	Mar. 5, 1953	Top of wooden platform	1.3
25.24.27.421	McClure and Hellyer	101	16	do.	I	1,320	ET	1951	3,701	56.8	Feb. 1, 1953	Top of casing	.5
25.24.27.423	Do.	100	-	Alluvium	U	-	N	-	3,685	39.1	Apr. 25,1952	-	-
25.24.27.434	Do.	300	-	do.	U	-	N	-	3,696	45.3	Apr. 25,1952	-	-
25.24.31.331	Anna Colwell	230	-	Alluvium	D,S	-	W	-	3,970	168.2	Jan. 19,1948	Top of casing	0.85
25.24.34.112	H. F. Ballard	97	-	do.	D,S	-	W	-	3,727	73.7	Jan. 19,1948	-	.9
25.24.34.112a	Do.	165	12	Alluvium (conglomerate)	I	450	ET	1951	3,739	89.8	Mar. 5, 1953	Top of casing	.9
25.24.34.124	Do.	165	12	do.	I	-	GT	-	3,714	64.5	Mar. 5, 1953	do.	1.5
25.25.4.144	G. R. Pipkin	-	-	Alluvium or Castile formation	S	-	W	-	3,570	53.1	Jan. 19,1948	Top of casing	.4
25.25.4.424	Paul Beedle	48	7	do.	D	-	W	-	3,550	36.5	Jan. 19,1948	Top of 4x4 timber	2.0

Table 1

Records of wells in upper Black River valley, Eddy County, New Mexico.--Continued

Location number (1)	Name or owner	Depth of well (ft.) (2)	Diameter (in.)	Principal aquifer	Use (3)	Yield (gpm) (4)	Method of lift (5)	Year completed	Altitude of land surface (ft.) (6)	Water level: Below land surface (ft.)	Water level: Date of measurement	Measuring point: Description	Measuring point: Distance above land-surface datum (ft.)
25.25.6.343	Old Stone place	10	-	Alluvium	S	-	W	-	3,625	9.0	Jan. 19,1948	Top of 3x3 timber SE side	1.0
25.25.12.342	R. G. Ozley	65	4	do.	D,S	-	W	-	3,410	33.1	Dec. 1, 1948	Top of casing	.5
25.25.16.141	C. R. Jones	85	8	do.	D	-	J	-	3,470	64.3	Nov. 6, 1953	Top of casing	1.0
25.25.16.144	Do.	-	8	Castile (?) formation	S	-	W	-	3,500	74.5	Apr. 29,1952	do.	1.0
25.26.7.444	R. G. Ozley	70	6	Alluvium (?)	U	-	W	-	3,340	47.1	Dec. 1, 1948	Top of wood block	.5
25.26.19.111	-	-	8	Castile (?) formation	S	-	W	-	3,410	69.9	Nov. 19,1949	Top of casing	1.5
26.24.3.341	A. J. Mayes	121	8	Alluvium	I	-	GT	1946?	3,713	30.1	Apr. 4, 1952	Top of casing	.9
26.24.4.113	-	-	-	do.	S	-	W	-	3,812	115.3	Apr. 27,1952	do.	.5
26.24.9.111	Bradley	595	10	Bell Canyon (?) formation	I	1,250R	GT	1952	3,805	101.9	June 18,1952	do.	3.3
26.24.9.331	Thurman	-	-	Alluvium	U	-	N	-	3,780	65.3	Jan. 26,1948	Top of casing	.7
26.24.9.421	Old School house	-	6	do.	D,S	-	W	-	3,746	49.1	Apr. 2, 1952	Top of casing	.6
26.24.9.441	John Mayes	100	12	Alluvium	I	-	GT	1951	3,749	44.4	Jan. 31,1953	Top of concrete pump base	0.6
26.24.10.131	A. J. Mayes	129	12	do.	I	800R	GT	1950	3,726	33.4	Feb. 1, 1953	Top of casing	1.0
26.24.10.243	A. M. Leeman	100	6	Alluvium (?)	S	-	W	-	3,716	19.2	Apr. 6, 1952	do.	2.2
26.24.10.321	Do.	400±	10	Alluvium and Castile formation		800R	GT	1950(?)	3,724	20R	Apr. 2, 1952	-	-
26.24.10.341	Do.	350±	16	do.	I	-	GT	1951	3,727	25.1	Jan. 31,1953	Top of casing	1.7
26.24.11.314	Do.	60	-	Castile formation	S	-	W	-	3,730	21.9	Jan. 22,1948	Notch in casing	.1
26.24.19.431	Do.	196	-	Alluvium	D,S	-	W	-	3,880	57.7	Jan. 22,1948	Top of 4x4 timber	1.0
26.24.28.413	Do.	90	-	do.	S	-	W	-	3,790	68.6	Jan. 22,1948	Top of casing	1.1

Table 2

Records of springs in upper Black River valley, Eddy County, N. Mex.

1. Location number described in text p. 6. S denotes spring.
2. Altitudes estimated from topographic map given to nearest foot; those determined by instrumental leveling given to nearest 0.1 foot.
3. Estimated yields denoted by E; other yields listed are measured and given in Table 4.
4. Use of water: D, domestic; I, irrigation; U, unused; PS, Public supply; S, stock.

Location number (1)	Name	Altitude (ft.) (2)	Source aquifer	Yield (gpm) (3)	Use of water (4)	Remarks
S24.26.23.441	Castle Springs		Conglomerate	180-270	I	Tributary to Black River. Part of flow is return from irrigated lands.
S24.26.33.122	Blue Spring	3,320	Conglomerate	5,000 - 6,300	I	Issues as large boils.
S25.24.12.324	-	3,640	Gypsum	3E	S	Seeps maintain pool about 500 feet in length.
S25.24.23.343	Rattlesnake Springs	3,636.1	Conglomerate	860 - 1,900	I,PS	Developed springs. Supplies water for use at Carlsbad Caverns.
S25.25.7.244	-	3,560	Gypsum	.5E	S	Seeps maintain small pool.
S26.23.29.332	XT Spring	4,350	Alluvium	50E	D,S	
S26.23.35.121	Geyser Spring	4,120	Alluvium	2,000E	D,S,I	
S26.24.3.423	-	3,675	Alluvium	250E	U	Issues as boil in pool tributary to Black River.

Table 3

Chemical analyses of water from wells, springs, and Black River in Tps. 24-26S., Rgs. 24 to 26 E., Eddy County, New Mexico

(Analyses by U. S. Geological Survey)

Location number described in text on page 6; S denotes spring; R denotes river station. Undesignated number denotes well.

Location number (1)	Name or owner	Date of collection	Parts per million: Bicarbonate (HCO_3)	Parts per million: Sulfate (SO_4)	Parts per million: Chloride (Cl)	Parts per million: Hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)
S24.26.23.441	Castle Springs	10/20/53	231	797	12	-	1,620
S24.26.33.122	Blue Spring	10/27/47	238	580	10	796	1,300
R24.26.35.141	Black River above Blue Spring	9/21/53	248	1,200	11	-	2,140
25.24.11.211	-	9/4/52	200	1,560	16	-	2,520
S25.24.12.324	-	9/4/52	123	1,550	11	-	2,400
25.24.16.410	-	5/16/52	189	1,480	9	1,680	2,420
25.24.19.421	-	5/16/52	274	36	4.5	257	480
S25.24.23.343	Rattlesnake Springs	1/26/48	287	120	6	362	651
Do.	do.	4/6/52	283	-	6	362	673
R25.24.24.332	Black River	4/25/52	224	672	7	848	1,410
R25.24.25.111	Above lower diversion	11/16/53	221	1,230	7	-	2,110
25.24.26.121	State Department of Game and Fish	10/1/52	286	105	6	333	619
25.24.26.334	McClure and Hellyer	5/15/52	220	1,410	7	1,580	2,320
25.24.27.124	do.	6/18/52	296	39	5	283	523
25.24.27.132	George Smart	5/15/52	259	144	16	351	694
25.24.27.421	McClure and Hellyer	4/6/52	252	621	8	840	1,380
25.24.31.331	Colwell Ranch	5/15/52	287	72	10	306	578
25.24.34.112a	H. F. Ballard	4/4/52	243	565	10	774	1,310
R25.24.35.143	Below upper diversion	9/21/53	231	1,280	7	-	2,190
25.24.35.321	Black River	4/25/52	200	1,080	7	1,250	1,920
25.25.12.342	R. G. Ozley	11/20/53	-	1,520	1	-	2,050
25.25.16.141	C. R. Jones	11/6/53	259	527	5	750	1,040
R26.24.3.244	Near Mayes ranch	9/21/53	222	1,290	7	-	2,200
26.24.3.341	Arthur Mayes	6/18/52	230	1,110	9	1,350	2,010
S26.24.3.423	-	5/14/52	200	1,260	8.5	1,440	2,160
26.24.3.424	-	5/14/52	229	1,450	8	1,660	3,370
R26.24.3.440	Black River	4/6/52	136	1,690	7	1,860	2,590
26.24.4.110	-	5/15/52	275	29	7	253	482
26.24.9.331	Thurman ranch	1/26/48	296	647	14	920	1,520
26.24.10.131	Arthur Mayes	4/6/52	228	1,270	8	1,480	2,170
26.24.10.243	A. M. Leeman	4/24/52	223	1,610	28	1,770	2,640
26.24.10.321	do.	4/6/52	238	1,480	8	1,740	2,460
S26.24.11.122	Bottomless lakes 1/	1/22/48	238	1,560	10	1,830	2,540
Do.	2/	4/6/52	132	-	42	3,260	4,270
26.24.11.314	A. M. Leeman	1/22/48	215	1,560	11	1,810	2,540
26.24.28.413	do.	1/28/48	252	134	8	358	653

1/ Collected from spring (dry in April 1952).
2/ Collected from pond.

Table 4

Periodic measurement of flow of Blue Spring, Castle Springs, Rattlesnake Springs, and Black River, Eddy County, New Mexico.

Measurements made by Geological Survey, unless otherwise noted.

(Discharge, cubic feet per second)

Name and location	Blue Spring Creek, above all diversions C, SW¼, sec. 27, T. 24 S., R. 26 E.	Castle Springs, above Black River village. SE¼SE¼, sec. 23, T. 24 S., R. 26 E.	Rattlesnake Springs. SE¼SW¼, sec. 23, T. 25 S., R. 24 E.	Black River, above mouth of Blue Spring Creek. SE¼NW¼ sec. 35, T. 24 S., R. 26 E.	Black River, below lower diversion dam, at road. SE¼NW¼, sec. 24, T. 25 S., R. 24 E.	Black River, above lower diversion dam. NW¼NW¼, sec. 25, T. 25 S., R. 24 E.	Black River, below upper diversion dam. SE¼NW¼, sec. 35, T. 25 S., R. 24 E.	Black River, below Mayes Ranch. NE¼SE¼, sec. 3, T. 26 S., R. 24 E.
1952								
Mar. 11	12.6	-	-	-	-	-	-	-
Apr. 25	13.3	-	a3.5	-	-	-	-	-
May 15	-	-	3.0	-	-	2.1	2.2	-
June 18	-	-	a3.1	-	-	-	-	-
25	-	-	-	-	0	a1.0	(b)	-
July 21	-	-	3.7	-	-	-	-	-
Aug. 1	-	-	2.4	-	.5	1.9	(b)	-
Sept. 5	-	-	a2.0	-	0	-	-	-
24	-	-	-	-	0	3.0	2.0	-
Oct. 15	13.5	-	3.4	-	.1	2.6	2.3	-
Nov. 14	13.2	-	3.9	-	.2	2.7	2.4	-
Dec. 31	11.9	-	4.2	-	.1	2.8	2.3	-
1953								
Jan. 23	13.8	-	3.3	-	.1	2.5	(b)	-
Feb. 20	12.2	-	-	-	1.3	5.6	5.5	-
Mar. 19	12.4	-	4.0	.3	.7	3.2	2.1	.9
Apr. 14	12.5	-	2.5	-	.8	2.6	1.6	-
May 19	12.9	.6	2.9	.2	0	2.5	c.9	1.0
June 16	12.4	.5	-	.3	0	2.4	2.2	.8
July 15	11.5	.4	-	.2	-	-	-	-
July 23	-	-	2.6	-	0	1.6	1.5	1.0
Aug. 24	11.4	.5	1.9	.1	0	.3	d1.0	1.0
Sept. 21	11.1	.3	2.4	.1	0	.6	1.0	1.0
Oct. 20	10.8	.6	2.3	.4	0	1.7	1.5	1.1
Nov. 16	11.3	1.3	-	.5	0	1.8	1.8	.7
27	-	-	3.5	-	-	-	-	-
Dec. 15	13.3	1.6	3.1	.3	0	2.3	2.4	.8
1954								
Jan. 14	12.2	2.3	3.4	.3	0	2.6	2.5	.6
Feb. 18	12.9	1.8	3.4	.3	0	1.9	2.8	.6
Mar. 22	12.6	1.2	2.5	.3	0	1.8	1.8	1.0
Apr. 26	12.5	.6	2.2	1.7	0	1.4	1.9	.7
May 29	11.9	.6	2.0	.3	0	.5	.8	.7
June 17	11.5	.6	1.7	.2	0	1.3	2.0	.7

a. Measurement made by Geological Survey, Ground Water Branch.
b. Diverting water through canal.
c. Recent diversion of water through canal.
d. Pool below level of spillway. No diversion for 3 days.

Table 5

Records of water-level measurements in observation wells in upper Black River valley, Eddy County, New Mexico.

25.24.23.343. National Park Service. Dug, observation well in alluvial sand and gravel, diameter 4 inches, depth 3.5 feet. Water level affected by change in stage of Rattlesnake Springs pool 50 feet to east. Measuring point is top of casing, altitude 3,635.87 feet, 0.4 foot above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Sept. 6, 1952	2.16	Dec. 17, 1952	.75	July 22, 1953	2.33	Mar. 8, 1954	.41
7	2.25	Feb. 1, 1953	0.28	Aug. 27	2.47	May 6	1.91
12	.49	Mar. 5	1.12	Nov. 10	0.76		
20	2.24	Apr. 23	1.09	Dec. 14	1.02		
Oct. 23	.52	June 5	1.93	Jan. 19, 1954	.45		

25.24.23.343a. National Park Service. Dug, observation well in alluvial silt, diameter 4 inches, depth 18.0 feet. Measuring point is top of casing, altitude 3,639.87 feet,1.6. feet above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Sept. 5, 1952	6.92	Oct. 23, 1952	5.84	June 5, 1953	6.38	Jan. 19, 1954	5.00
6	6.86	Dec. 17	4.91	July 22	6.76	Mar. 8	4.94
7	6.83	Feb. 1, 1953	4.78	Aug. 27	7.56	May 6	5.66
12	6.52	Mar. 5	4.91	Nov. 10	5.70		
20	6.84	Apr. 23	5.76	Dec. 14	5.37		

25.24.23.343b. National Park Service. Dug, observation well in alluvial silt, diameter 4 inches, depth 7.5 feet. Measuring point is top of casing, altitude 3,636.74 feet, 1.9 feet above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Sept. 12, 1952	6.55	Feb. 1, 1953	4.78	July 22, 1953	6.72	Mar. 8, 1954	5.04
20	6.45	Mar. 5,	5.21	Nov. 11	5.70	May 6	5.26
Oct. 23	6.24	Apr. 23	5.76	Dec. 14	5.41		
Dec. 17	4.81	June 5	6.44	Jan. 19, 1954	4.22		

25.24.26.121. -/ State Department of Game and Fish. Dug, unused well in alluvial conglomerate, diameter 24 inches, depth 15.4 feet. Measuring point is top of casing, altitude 3,639.39 feet, 3.0 feet above land-surface datum. Recording gage installed Feb. 6, 1953.

Depth to water in feet above (+) or below (-) land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
1952		1952--Con.		1952--Con.		1952--Con.	
Sept. 10	-0.93	Sept. 20	-.19	Sept.25	-.38	Dec. 17	+0.50
12	-.72	Sept. 24	-0.31	Oct. 23	+.25	1953	
						Mar. 5	+.52

-/ Additional water-level data given in Table 6.

25.24.26.334. McClure and Hellyer. Drilled, stock well in alluvium (?), diameter 6 inches. Measuring point is top of concrete base, altitude 3,675 feet, 1.1 feet above land-surface datum.

Water level in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
June 18, 1952	36.76	Mar. 5, 1952	36.47	Aug. 27, 1953	36.82	Jan. 19, 1954	43.35
Oct. 23	36.50	Apr. 23, 1953	37.38	Sept. 30	37.73	Mar. 8	36.22
Dec. 17	36.24	June 11	37.42	Nov. 12	36.95	May 6	37.85
Feb. 1, 1953	36.69	July 22	36.14	Dec. 14	34.93		

Table 5

Records of water-level measurements in observation wells in upper Black River valley, Eddy County, New Mexico.--Continued

25.24.27.124. McClure and Hellyer. Drilled, irrigation well in alluvial conglomerate, reported depth 150 feet. Measuring point is base of timber pump base, altitude 3,738.9 feet, 0.4 foot above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1952	93.56	Sept. 8, 1952	96.60	Feb. 1, 1953	94.46	Jan. 20, 1954	95.19
May 21	94.55	Sept.24	95.99	Mar. 5	94.55	Mar. 8	95.27
July 2	94.61	Oct. 23	94.94	Apr. 23	95.99	May 6	117.6
15	95.05	Dec. 17	94.53	June 11	96.80		

25.24.27.132. George Smart. Drilled, unused well in alluvial conglomerate, diameter 10 inches, depth 137.0 feet. Measuring point is top of casing and concrete base, altitude 3,754.1 feet, 0.9 foot above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1952	118.06	July 22, 1952	117.97	Oct. 23, 1952	118.18	July 22, 1953	118.43
26	118.10	28	118.08	Dec. 5	118.21	Aug. 27	118.47
May 29	118.03	Aug. 10	118.09	17	118.20	Sept. 30	118.57
June 5	118.02	Aug. 27	118.07	Feb, 1, 1953	118.27	Nov. 12	118.55
11	118.03	Sept. 4	118.11	Mar. 5	118.28	Dec. 14	118.62
27	118.05	17	118.10	11	118.28	Jan. 20, 1954	118.56
July 2	118.03	24	118.17	Apr. 23, 1953	118.35	May 6	129.60
15	118.09	Oct. 1	118.13	June 5	118.38		

25.24.27.141. George Smart. Unused drilled well in alluvium, reported depth 165 feet. Measuring point is top of wood platform, altitude 3,750.6 feet, 1.3 feet above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Sept. 8, 1952	106.98	Mar. 18, 1953	105.11	June 22, 1953	106.52	Nov. 20, 1953	105.81
17	c109.58	Apr. 23	106.33	29	c109.32	Dec. 14	105.73
24	106.34	Apr. 28	c108.30	July 9	c109.36	Jan. 20, 1954	105.59
Oct. 1	105.92	24	106.48	15	c110.14	Mar. 8	105.76
23	105.28	May 1	c108.37	July 22	c110.03	May 6	110.42
Dec. 17	104.89	5	c108.63	Aug. 27	c110.78		
Mar. 5, 1953	104.84	June 5	c109.69	Sept. 30	107.44		
11	104.84	11	107.19	Nov. 12	105.86		

c Nearby well being pumped.

25.24.27.421. McClure and Hellyer. Drilled, irrigation well in alluvium, diameter 16 inches, reported depth 101 feet. Measuring point is top of casing, altitude 3,701 feet, 0.5 foot above land-surface datum. Land-surface datum is 3,701 feet above mean sea level.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1952	55.68	Sept. 24, 1952	57.61	Feb. 1, 1953	56.07	Jan. 19, 1954	56.66
May 21	55.86	Oct. 23	56.50	Nov. 10	57.05	Mar. 8	57.63
Sept. 8	58.41	Dec. 17	56.10	Dec. 14, 1953	57.12		

25.24.34.112a. H. F. Ballard. Drilled, irrigation well in alluvium, diameter 12 inches, reported depth 165 feet. Measuring point is top of casing, altitude 3,740 feet, 0.9 foot above land-surface datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1952	89.27	July 15, 1952	90.05	Dec. 5, 1952	89.90	Sept. 30, 1953	92.38
May 21	89.76	22	89.65	17	89.80	Nov. 12	91.06
29	90.00	Aug. 27	a94.80	Feb. 1, 1953	89.88	Dec. 15	90.86
June 5	89.94	Sept. 8	91.79	Mar. 5	89.78	Mar. 8, 1954	90.68
11	a93.10	17	91.86	Apr. 24	91.49	May 6	92.45
18	90.11	24	91.51	June 11	92.11		
27	90.02	Oct. 1	91.00	July 22	92.77		
July 2	89.88	23	90.31	Aug. 27	a96.69		

a Pumping.

Table 5

Records of water-level measurements in observation wells in upper Black River valley, Eddy County, New Mexico.--Continued

25.24.34.124. H. F. Ballard. Drilled, irrigation well in alluvium, diameter 12 inches, reported depth 165 feet. Measuring point is top of casing, altitude 3,715 feet, 1.5 feet above land-surfaoe datum.

Depth to water in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1952	63.84	July 15, 1952	64.59	Oct. 23, 1952	64.12	Aug. 27, 1953	c68.19
May 21	64.39	22	64.16	Dec. 5	64.54	Sept. 30	70.50
29	64.68	Aug. 27	c66.24	17	64.48	Nov. 12	64.60
June 5	64.57	Sept. 4	66.44	Mar. 5, 1953	64.47	Dec. 14	63.60
11	c65.06	24	66.11	Apr. 24	66.20	Jan. 20, 1954	65.24
27	64.64	Oct. 1	65.58	June 11	66.74	Mar. 8	65.33
July 2	64.45	14	65.12	July 22	66.97	May 7	67.06

c Nearby well being pumped.

26.24.9.421. "Old School House"well. Drilled, domestic and stock well in alluvium, diameter 6 inches. Measuring point is top of casing, altitude 3,747 feet, 0.6 foot above land-surface datum.

Water level in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 24, 1952	49.15	Dec. 17, 1952	50.6	Nov. 20, 1953	52.81	Mar. 8, 1954	52.99
June 16	49.64	Feb. 1, 1953	50.99	Dec. 15	53.12	May 7	53.82
Sept. 20	50.61	June 11	52.00	Jan. 20, 1954	52.85		

26.24.9.441. John Mayes. Drilled, irrigation well in alluvium, diameter 12 inches, reported depth 100 feet. Measuring point is top of concrete pump base, altitude 3,750 feet, 0.6 foot above land-surface datum.

Water level in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 4, 1952	43.13	Jan. 31, 1953	44.35	Oct. 2, 1953	46.28	Mar. 8, 1954	46.03
24	43.05	May 5	45.74	Nov. 12	46.01	May 7	47.50
June 16	43.25	June 11	45.38	Dec. 15	46.14		
Dec. 17	44.30	July 22	45.61	Jan. 20, 1954	45.81		

26.24.10.131. Arthur Mayes. Drilled, irrigation well in alluvium, diameter 12 inches, reported depth 129 feet. Measuring point is top of casing, altitude 3,727 feet, 1.0 foot above land-surface datum.

Water level in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 2, 1952	30.3	Feb. 1, 1953	33.37	Oct. 2, 1953	36.06	Mar. 8, 1954	35.68
24	31.48	June 11	34.24	Nov. 12	35.50	May 7	36.63
June 18	31.02	July 22	34.86	Dec. 15	35.51		
Dec. 17	33.7	Aug. 27	35.55	Jan. 20, 1954	35.53		

26.24.10.341. A. M. Leeman. Drilled, irrigation well in alluvium and Castile formation, diameter 16 inches, reported depth 350± feet. Measuring point is top of casing, altitude 3,729 feet, 1.7 feet above land-surface datum.

Water level in feet below land-surface datum

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Apr. 2, 1952	23.75	Dec. 17, 1952	27.30	Dec. 15, 1953	26.38	Jan. 20, 1954	26.18
25	25.69	Jan. 31, 1953	25.10			May 7	26.86
June 18	24.18	June 11	25.76				
Sept. 20	24.67	Nov. 12	26.02				

Table 6

Daily highest and lowest water level in feet above (+) or below (-) land-surface datum in well 25.24.26.121, Eddy County, New Mexico, 1953-54 (from recorder charts). 25.24.26.121. N. Mex. Dept. of Game and Fish. Dug, unused well in alluvial conglomerate, diameter 24 inches, depth 15.4 feet. Measuring point is top of casing, altitude 3,639.39 feet, 3.0 feet above land-surface datum. Recording gage installed Feb. 6, 1953.

1953

Day		Jan.	Feb.	Mar.	Apr.	May	June
1	High			+0.75	+0.21	-0.45	-0.57
	Low			.72	.02	.76	.92
2	High			.74	.09	.64	.78
	Low			.72	- .36	.88	1.04
3	High			.74	.32	.56	.87
	Low			.57	.63	.83	1.14
4	High			.57	.47	.45	.97
	Low			.53	.60	.56	1.15
5	High			.53	.37	.46	.93
	Low			.51	.63	.60	1.12
6	High			.56	.48	.47	.89
	Low			.50	.75	.57	1.14
7	High		+0.54	.61	.57	.39	.91
	Low		.42	.56	.85	.51	1.08
8	High		.61	.62	.71	.32	.70
	Low		.54	.58	.98	.46	.91
9	High		.62	.66	.83	.26	.60
	Low		.61	.62	1.08	.44	.94
10	High		.63	.66	.86	.40	.78
	Low		.62	.65	1.00	.53	.99
11	High		.64	.66	.67	.36	.43
	Low		.60	.65	1.01	.52	.79
12	High		.60	.64	.69	.32	.25
	Low		.58	.51	1.02	.50	.43
13	High		.66	.51	.90	.42	.14
	Low		.58	.45	1.12	.64	.25
14	High		.68	.45	.94	.48	.08
	Low		.66	.39	1.07	.64	.14
15	High		.70	.39	.87	.39	.06
	Low		.58	.37	1.01	.48	.14
16	High		.66	.37	.75	.37	.04
	Low		.65	.36	.87	.45	.13
17	High		.69	.37	.57	.30	.01
	Low		.66	.36	.78	.38	.04
18	High		.74	.39	.47	.31	+ .01
	Low		.69	.32	.57	.39	- .00
19	High		.76	.32	.46	.34	+ .03
	Low		.73	.29	.55	.46	- .02
20	High		.73	.32	.38	.40	+ .02
	Low		.71	.30	.53	.52	- .19
21	High		.71	.42	.38	.36	.19
	Low		.69	.32	.45	.51	.37
22	High		.70	.39	.35	.40	.21
	Low		.72	.32	.45	.86	.46
23	High		.75	.35	.26	.75	.30
	Low		.73	.32	.32	.99	.55
24	High		.75	+ .41	.31	.84	.35
	Low		.73	- .02	.44	.95	.59
25	High		.74	+ .22	.27	.84	.49
	Low		.72	- .28	.50	1.17	.62
26	High		.74	+ .30	.38	1.01	.40
	Low		.72	.20	.62	1.14	.59
27	High		.74	.34	.46	.86	.52
	Low		.73	.16	.69	1.16	.64
28	High		.75	.39	.54	.66	.46
	Low		.73	.29	.69	1.04	.80
29	High			.44	.32	.57	.68
	Low			.39	.56	.80	1.01
30	High			.39	.27	.62	.76
	Low			.22	.51	.88	1.10
31	High			.22		.66	
	Low			.19		.82	

Table 6

Daily highest and lowest water level in feet above (+) or below (-) land-surface datum in well 25.24.26.121, Eddy County, New Mexico. --Continued

1953

Day		July	Aug.	Sept.	Oct.	Nov.	Dec.
1	High	-0.84	-1.37	-1.66	-0.78	-0.02	+0.16
	Low	1.17	1.62	1.85	.89	.02	.12
2	High	.86	1.39	1.63	.68	+ .01	.18
	Low	1.24	1.63	1.79	.78	- .02	.16
3	High	1.07	1.43	1.58	.61	.01	.17
	Low	1.30	1.62	1.77	.68	.00	.14
4	High	1.10	1.38	1.57	.56	.04	.18
	Low	1.36	1.66	1.77	.61	+ .02	.14
5	High	1.11	1.47	1.61	.52	.07	.18
	Low	1.28	1.69	1.82	.56	.04	.15
6	High	1.02	1.49	1.61	.49	.08	.16
	Low	1.12	1.74	1.83	.54	.06	.12
7	High	.96	1.56	1.63	.53	.06	.13
	Low	1.16	1.78	1.85	.56	.04	.12
8	High	.92	1.56	1.70	.52	.05	.12
	Low	1.01	1.78	1.92	.55	.04	.07
9	High	.90	1.54	1.61	.50	.08	.16
	Low	1.19	1.76	1.80	.52	.05	.06
10	High	.91	1.56	1.59	.36	.07	.17
	Low	1.26	1.77	1.81	.50	.06	.13
11	High	.98	1.55	1.60	.32	.08	.17
	Low	1.11	1.77	1.80	.39	.07	.14
12	High	.91	1.57	1.60	.26	.08	.21
	Low	1.16	1.77	1.81	.36	.08	.16
13	High	1.00	1.54	1.55	.22	.09	.21
	Low	1.28	1.73	-	.26	.08	.17
14	High	1.11	1.51	-	.20	.10	.17
	Low	1.37	1.66	-	.26	.09	.15
15	High	1.19	1.46	-	.23	.12	.19
	Low	1.42	1.71	-	.26	.08	.18
16	High	1.14	1.48	-	.22	.18	.18
	Low	1.34	1.72	-	.24	.08	.15
17	High	1.06	1.52	1.54	.20	.17	.18
	Low	1.16	1.75	1.77	.22	.15	.18
18	High	.89	1.53	1.36	.17	.20	.20
	Low	1.12	1.77	1.70	.20	.17	.18
19	High	.82	1.55	1.21	.14	.22	.24
	Low	.95	1.81	1.36	.20	.05	.18
20	High	.89	1.62	1.11	.13	+ .05	.33
	Low	1.01	1.97	1.21	.14	- .29	.24
21	High	.89	1.65	1.02	.11	+ .05	.48
	Low	1.22	1.85	1.11	.12	- .38	.33
22	High	1.09	1.65	.94	.08	+ .17	.34
	Low	1.34	1.90	1.02	.11	.05	.32
23	High	1.18	1.60	.86	.04	.24	.35
	Low	1.39	1.80	.94	.08	.12	.33
24	High	1.20	1.51	.77	.05	.22	.38
	Low	1.47	1.79	.88	.06	.18	.35
25	High	1.28	1.62	.72	.04	.18	.40
	Low	1.52	1.82	.89	.06	.14	.38
26	High	1.31	1.62	.68	.06	.14	.45
	Low	1.52	1.85	.84	.08	.13	.40
27	High	1.28	1.63	.64	.08	.13	.45
	Low	1.48	1.84	.85	.08	.12	.38
28	High	1.25	1.65	.76	.07	.12	.41
	Low	1.50	1.89	.98	.08	.11	.38
29	High	1.28	1.71	.82	.04	.11	.43
	Low	1.52	1.91	.94	.07	.10	.38
30	High	1.31	1.67	.89	.03	.13	.38
	Low	1.51	1.87	1.06	.04	.10	.36
31	High	1.30	1.66		.02		.42
	Low	1.55	1.87		.03		.38

Table 6

Daily highest and lowest water level in feet above (+) or below (-) land-surface datum in well 25.24.26.121, Eddy County, New Mexico. -- Continued

1954

Day		Jan.	Feb.	Mar.	Apr.	May	June
1	High	+0.44	+0.40	-	+0.25	-0.40	-0.52
	Low	.42	.34	-	.23	.53	.57
2	High	.44	.34	-	.28	.46	.48
	Low	.38	.32	-	.15	.53	.62
3	High	.43	.34	-	.32	.42	.59
	Low	.38	.31	-	.29	.50	.65
4	High	.42	.32	-	.32	.44	.56
	Low	.40	.31	-	.12	.83	.69
5	High	.42	.42	-	.18	.74	.53
	Low	.41	.31	-	.12	1.03	.69
6	High	.43	.44	-	.19	.88	.46
	Low	.42	.42	-	.04	1.13	.53
7	High	.44	.44	-	+ .10	.92	.42
	Low	.43	.44	-	- .11	1.16	.66
8	High	.44	.45	-	.06	.94	.62
	Low	.44	.43	+0.32	.26	1.16	.71
9	High	.44	.44	.32	.10	.72	.56
	Low	.43	.42	.30	.40	1.04	.68
10	High	.43	.44	.30	.29	.64	.59
	Low	.40	.42	.28	.60	.89	.82
11	High	.43	.44	.31	.44	.76	.73
	Low	.40	.37	.28	.64	.89	.88
12	High	.43	.38	.32	.43	.73	.67
	Low	.42	.36	.28	.59	.85	.92
13	High	.44	.40	.28	.45	.65	.68
	Low	.43	.38	.25	.69	.80	.92
14	High	.44	.41	.31	.53	.68	.59
	Low	.44	.38	.28	.78	.81	.92
15	High	.45	.38	.31	.64	.68	.79
	Low	.42	.32	.28	.88	.80	.40
16	High	.44	.32	.29	.75	.54	.82
	Low	.42	.31	.28	.96	.76	1.00
17	High	.46	.40	.34	.80	.48	.84
	Low	.44	.32	.29	1.05	.85	1.15
18	High	.46	.44	.34	.68	.74	1.16
	Low	.39	.40	.31	1.00	.84	1.44
19	High	.41	.43	.31	.66	.69	1.43
	Low	.39	.41	.29	.90	.95	1.53
20	High	.42	.43	.33	.78	.80	1.20
	Low	.40	.41	.31	1.09	.90	1.53
21	High	.42	.43	.32	.94	.76	1.05
	Low	.40	.33	.29	1.19	.90	1.20
22	High	.47	.46	.29	1.03	.74	1.08
	Low	.42	.40	.27	1.25	.86	1.40
23	High	.48	-	.30	1.09	.58	1.43
	Low	.46	-	.26	1.27	.74	1.60
24	High	.46	-	.31	1.08	.51	1.43
	Low	.45	-	.28	1.30	.59	1.46
25	High	.46	-	.30	.84	.52	1.51
	Low	.30	-	.27	1.15	.59	1.62
26	High	.34	-	.32	.70	.52	1.44
	Low	.22	-	.30	.84	.70	1.61
27	High	.35	-	.32	.53	.65	1.25
	Low	.34	-	.30	.70	.75	1.61
28	High	.36	-	.33	.42	.67	1.25
	Low	.35	-	.32	.53	.88	1.42
29	High	.36	-	.33	.35	.74	1.30
	Low	.34		.29	.42	1.02	1.57
30	High	.36		.28	.34	.69	1.40
	Low	.34		.26	.43	1.00	1.56
31	High	.37		.27		.57	
	Low	.34		.26		.70	